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# Science Teaching and Learning as Transformation: Making Meaning with My Students

Megan Marie Leider

*Loyola University Chicago*

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LOYOLA UNIVERSITY CHICAGO

SCIENCE TEACHING AND LEARNING AS TRANSFORMATION:  
MAKING MEANING WITH MY STUDENTS

A DISSERTATION SUBMITTED TO  
THE FACULTY OF THE GRADUATE SCHOOL OF EDUCATION  
IN CANDIDACY FOR THE DEGREE OF  
DOCTOR OF EDUCATION

PROGRAM IN CURRICULUM AND INSTRUCTION

BY

MEGAN M. LEIDER

CHICAGO, ILLINOIS

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I am grateful for so many people who have encouraged and inspired me throughout my life and this process. I first want to thank my parents. My dad was my first science teacher. He instilled in me the love for understanding the wonder and order of life. I also inherited his organizational skills which were imperative in getting me through this process. Last, he made sure I knew the importance of “turning off these lights for crying out loud” and “not leaving your shoes everywhere for Christ’s sake.” My mom was my loudest cheerleader and always thought I was so smart even when at age 15 I glued a solo cup to my forehead. Their unwavering support and love has made me who I am today and I am more thankful for them than they will ever know. I also like to thank my brothers, Brian and Nick. They have been “allowing” me to tell them what to do for three plus decades. They also help keep me grounded with their wit, friendship, and memories surrounding my awkward phase – which lasted 25 years.

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dissertation. Dr. Ryan was there to challenge my thinking and to listen to me whine about miniscule details that did not matter whatsoever. Dr. Ryan also introduced me to the power of self-study and validated who I was inside and outside the classroom.

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## DEDICATION

I dedicate this to my mom. We began this journey together seven years ago and I know she is with me in spirit as we finish. Growing up, my mom was full of encouraging phrases such as “you should really clip your bangs off your face” or “you are not buying those shoes – those are for streetwalkers” as well as “you can do anything you want” and more recently “I am so proud of the woman you have become.” Thank you for everything, Mommy.

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## ABSTRACT

As a classroom science teacher, I have experienced firsthand the disengagement and disinterest students have with science. Students often struggle to retain information from year to year, feel comfortable in the science classroom, and see the connections between the science taught in the classroom and their lived experiences. It is obvious to me that we could do more for our students. One way in which to assist students with science learning is through the incorporation of Sci-YAR (Science Youth Action Research). Sci-YAR is a curricular framework and instructional strategy that places the student at the center of their learning. It requires students to engage in collaborative action-based scientific inquiries rooted in issues that are of great importance to the students. Sci-YAR challenges the traditional role of student and teacher and has the capacity to transform both the students and the teachers. The purpose of this study is to investigate how students and their teacher make meaning of their experiences while engaging in Sci-YAR. This study was conducted in my classroom with myself and several of my students as participants and offers an emic perspective of science teaching and learning. I hope to contribute to the literature on practitioner inquiry, the power of student voice and rethinking science teaching and learning.

## CHAPTER I

### INTRODUCTION

#### **Statement of the Problem**

Science education has historically supported the perspective that children are like empty vessels waiting to be filled with science knowledge (Emdin, 2009). The assumption is that if teachers deliver the material in a clear and concise manner, then the students will learn regardless of their backgrounds, socio-economic statuses, interests, and cultures. The image of science teachers is that described by Freire's (1970) banking system in which the teachers are the keepers of the knowledge and it is their job to deposit the information into students' minds. This approach often serves to maintain a power dynamic in which the students are dependent on the teacher, leaving the teacher with the sole responsibility for student learning. Images of the typical science classroom usually include a teacher standing in the front of the room next to a chalkboard full of complicated diagrams and formulas as the students intently look on and take notes. Those of us whose classrooms look quite different are forced to ask ourselves: Is the banking model the best approach to teaching science? Is this really what science teaching should look like?

Currently, science education is failing to engage our students, especially those in the middle and upper grades. Unfortunately, fewer and fewer American students are interested in pursuing science related careers (Osborne, Simon & Tytler, 2009). This issue of student disinterest and disengagement with science is nothing new; the American

Association for the Advancement in Science (AAAS, 1989) warned that most Americans are not science-literate, stating that most U.S. students rank near the bottom in science and math achievement compared to other industrial countries. AAAS (1989) also argued that science education needs to become more accessible to all students. In particular it emphasized the inclusion of those students who may have been previously marginalized in the science classroom – for instance female, minority, and non-English speaking students. These conclusions formed almost thirty years ago are still relevant today. This issue of students falling behind in interest and achievement in science has now crossed generations making it even more worthy of our attention.

Recent standardized test data would indicate that students are experiencing high levels of disengagement. For instance, according to the Programme for International Student Assessment (PISA), in 2012 United States students were below average among the 65 participating countries (OECD, 2013). The 2011 Trends in International Mathematics and Science Study (TIMSS) survey reiterates the United States' continued mediocrity in science achievement (International Association for the Evaluation of Educational Achievement [IEA], 2012). The TIMSS assesses student achievement from all over the world. In 2011, the United States was tenth out of 42 countries in overall science achievement. Furthermore, the U.S. was outperformed by Asian countries on most benchmarks (IEA, 2012).

Low performance on these tests is one indication that students are suffering from a lack of engagement in science learning. The responsibility for this disengagement is in the hands of teachers, administrators and university professionals and their lack of

effective and thoughtful instruction. For instance, research indicates that science teaching is not tailored to individual learning styles and the overall needs of students (Osborne, Simon & Tytler, 2009). The science education community currently lacks a single vision as to the purpose of science instruction. For instance, is it to create science professionals (engineers, doctors, etc.) as a means to an end or is constructing scientific knowledge an end unto itself (Osborne, 2008)? In order to aid students in developing an understanding of science that includes the construction of scientific knowledge and to encourage students to productively participate in science as adults, we as educators must convey why science is important, excite students by helping them investigate what they do not know, and allow students to have authentic science learning experiences (Osborne, 2008). I argue that it is a lack of opportunity and authentic experiences in science that keeps students disengaged.

In my 13 years of teaching, it has become clear that the science education community can do more for our students. When students enter the classroom they arrive possessing their own thoughts, behaviors, cultures, languages and values. Asking students to put these factors aside assumes that students are blank slates which ignores and devalues the students as thinkers and as individuals. I have seen many highly intelligent students struggle with science, not because they did not understand the material, but rather because they felt so far removed from it. It had been drilled into their consciousnesses that science was something only a select few could do (Emdin, 2010). Many students falsely believe that they are not scientists. For instance, the media is full of images of scientists being White males; very rarely will television shows and movies

portray scientists as ethnic minorities, working class citizens or women (Barton & Yang, 2000).

Gonzalez, Moll and Amanti (2005) argue that learning is a cultural – not solely cognitive – process. They state that by using the diversity of students' cultures to inform instructional practices, greater resources become available to the classroom. In addition, the educational experiences of students and teachers are greatly enhanced when teachers learn about their students and use their students' cultural practices to strengthen learning opportunities. This stance is currently reflected in the Next Generation Science Standards (NGSS). The NGSS emphasize a student centered approach to science teaching and learning. The NGSS were developed in large part by the National Research Council (NRC). The NRC's publication, *A Framework for K-12 Science Education: Practices Crosscutting Concepts, and Core Ideas*, outlines their approach to science learning and calls for a more concerted effort to educate all students. In addition, the NRC continues to emphasize that educators actively engage students in science and engineering because science is important for every individual as well as our communities and society (NRC, 2012). The NGSS argue for more attention to be paid to students' needs especially with regards to providing adequate context for scientific knowledge and application of this knowledge (Appendix A: Conceptual Shifts in the Next Generation Science Standards, 2013). The science education community from educators, to psychologists, to policy makers need to work together to make science more accessible by placing the students at the center of the instruction.



One way in which to place students at the center of the instruction; to draw on the diversity of students' lived experiences; and to make science accessible to all students, is to position students as the experts in the classroom. We, as educators, must work to give students a more active role in their learning and help students uncover connections between scientific thinking and their lived experiences. This can be achieved by incorporating Science Youth Action Research (Sci-YAR) into the curriculum. Sci-YAR, as defined by Coleman (2014), is an instructional approach that engages students in collaborative action-based scientific inquiries. These inquiries are rooted in issues that are of great importance to the students. I argue that adopting Sci-YAR as a curricular framework has the potential to increase student engagement both inside and outside of the classroom, and also transform the teacher implementing it.

### **Background for the Study**

Several years ago, I found myself struggling with my instruction and my role as a teacher. I witnessed many of my students participate productively in science in my classroom and then struggle in their subsequent science classes. Nothing I was doing was producing meaningful long lasting connections. At this point, I knew I needed to radically change the way I envisioned good science teaching and learning. It was at this time that I reached out to Elizabeth Coleman at Loyola University Chicago, and we began the long process of developing the Sci-YAR curriculum. It has been through the implementation of this Sci-YAR curriculum that I have seen my students become more engaged in science and in turn develop deep understandings of how scientific knowledge is constructed.

**Sci-YAR**

This unique curriculum is designed to enable students to participate in authentic science learning experiences and to become experts in the classroom. Sci-YAR has several key features intended to promote relevance and student agency including using science as a way of knowing and taking action; participating in relevant practices of science through action research; engaging in extensive personal reflection; collaborating through collective research; and conducting research that is youth-generated and youth-led (Coleman, 2014). During the implementation of the curriculum, which spans over six months, students assume the roles of researchers and as experts as they investigate a scientific problem of their choosing related to their lives or their community.

This curriculum also changes my role in the classroom. I am no longer the one in the front of the room giving information to my students. Instead, I am a facilitator acting as my students' advisor as they conduct their own research. For instance this past year, several students wished to research the impact of drugs in their communities. They created three research questions, designed a research plan which consisted of interviews with family and community who have been impacted by drug use, and conducted these interviews. The students then listened to and coded the interviews which allowed them to form conclusions answering their original three research questions. In the case of these students and all my students, I was there to lend my support, to check their research plan and interview questions and to challenge their thinking when completing their findings. The research from start to finish was conducted by my students, not by me.

## **Critical Theory**

Power structures exist in science classrooms, whether it is the notion that the teachers are the only ones who possess the knowledge or that science is reserved for only the highly intelligent. These power structures shape students' social interactions, which in turn impact their learning (Barton & Tan, 2010). By positioning students as researchers and as experts in their classrooms through the Sci-YAR curriculum, the traditional roles that students and teachers have played in science education, as well as the power structures in the classroom, are challenged. I am using a critical theory lens to conduct my research in order to further investigate how these power structures impact my and my students' experiences with Sci-YAR. I will also use critical theory to examine issues with power, justice, race, economics and class associated with re-positioning the students as researchers, and their changing views of the construction of scientific knowledge.

Science is a way of knowing: the ways in which scientists collect information through scientific investigations and then form conclusions (Crowther, Lederman & Lederman, 2005; Lederman, El-Khalick, Bell & Schwartz, 2002). For many students, the idea that they can partake in scientific investigations is new. Many students find science too difficult and view it as a topic that is only accessible to select students (Emdin, 2010). Thus, many are left feeling that their understandings of science are not valuable. These negative experiences shape the amount and type of resources to which individuals have access. In actuality, science is a socio-cultural construct and thus scientific knowledge

can and does emerge from different interpretations of data (Lederman et al., 2002). In turn, science should be made more available to all students.

### **Purpose of Study**

This multifaceted study has three primary goals. First, I intend to examine my experiences and my students' experiences engaging in Sci-YAR. I have observed as a classroom teacher that students become more engaged in learning science when they uncover that science can be a creative, messy, and ever-changing process. For me, an integral part of Sci-YAR has been positioning my students as researchers. When the students become the experts and the researchers in the classroom, they are also given the opportunity to make more choices regarding the content they study and the methods by which they study. According to Velez-Ibanez and Greenberg (1992) this opportunity provides students a zone of comfort – where error is not dealt with punitively, and where self-esteem is not endangered. When I increase the number of choices students can make in the classroom, I am more likely to see students running to my class, excited about learning and becoming critical thinkers.

Michaels, Shouse, and Schweingruber (2007), in association with the National Research Council (NRC), have identified four aspects critical to science learning. In order for students to become highly proficient in science they must (a) understand scientific explanations or use scientific content knowledge in new situations, (b) generate scientific evidence by evaluating this evidence in order to form conclusions, (c) reflect on scientific knowledge and further explore how scientific knowledge is generated, and (d) participate productively in science by interacting with peers to form scientific learning

communities. According to NRC, students can best meet these four tenets when given the opportunity to develop deep and personal relationships with the topics they have chosen to study. One way to create these opportunities is to give students more choice in the content they wish to investigate.

The second purpose to this study is to empower myself and my students through research. Giving the students more choice helps to disrupt the status quo. In the typical science classroom the teacher holds the power and is viewed as the gatekeeper of knowledge. This view also suggests that science is something people know; it's a collection of facts, a body of knowledge. In actuality, science is something people do (Bransford & Donovan, 2005). According to Lederman (2007), science is a subjective enterprise, involves imagination, and is culturally and socially embedded. These ideals are incorporated into my teaching with the help of Sci-YAR and are intended to help my students realize that they can participate in scientific practices just as the elite nuclear scientists can do science – although I am not ready to unleash the particle accelerator unto my students just yet. I also fully intended to become empowered through this research as well. By challenging traditional approaches to science education and examining my own practice in doing so, I am challenged to grow as a teacher and as a researcher.

Last, my goal in conducting this study is to give an emic perspective on teaching science and on implementing an innovative curriculum. This emic perspective is lacking in discussions of and in research regarding science education. Teacher voice is missing in a survey of the current literature. More insider accounts as to the realities of the

science classroom can potentially help us to gain a deeper understanding of the essential issues, such as why students are struggling with science in K-12 classrooms and why they are reluctant to pursue science related careers. According to Cochran-Smith and Lytle (2009), inquiry into one's own practice is complex and sensitive but is the only way in which to gain the unique and important knowledge of being a practitioner in a twenty-first century classroom.

A few years ago, I reached a place in my teaching where I became bored with teaching science in the traditional manner, which included long dry lectures and unimaginative lab experiments. When I began to re-think science teaching and learning, my teaching changed for the better. I have witnessed as a teacher how Sci-YAR can change students' perceptions of science learning as well as the teachers' experiences and understandings as well. My passion for teaching and learning science was renewed when I realized that science is an active, creative, all-inclusive endeavor. In a previous self-study, I was able to experience the challenges of pushing myself out of my comfort zone as well the growth I experienced as a teacher, a researcher and an individual (Coleman & Leider, 2013). I became a better science teacher when I adopted Sci-YAR as an instructional approach. My goal with this study is to give an insider's account of the transformation that can accompany Sci-YAR's implementation.

### **Research Questions**

The following questions will be investigated through this study:

1. How has my teaching changed over the past four years?

2. How do I make meaning of my experience engaging in the Sci-YAR curriculum?
  - a. What am I learning about myself as a teacher and my students when they experience Sci-YAR instruction?
  - b. What are my reactions while engaging my students in Sci-YAR?
  - c. How does teaching Sci-YAR affect other areas of my life?
3. How do my students make meaning of their experiences while engaging in the Sci-YAR curriculum?
  - a. What are my students learning about themselves when they experience Sci-YAR instruction?
  - b. What are my students' reactions to Sci-YAR?
  - c. How does Sci-YAR affect other areas of my students' lives?
4. How does engaging in Sci-YAR impact me and my practice as I move forward in my career?

### **Considerations**

Qualitative research assumes that multiple perspectives of reality exist (Merriam, 1995). This study offers my perspective of reality. Multiple methodologies will be used in this study in order to capture the varying perspectives of students and teacher. I will be employing the use of self-study and phenomenology to conduct my research. I do not expect my research or my findings to hold true for every science classroom in every school across the United States. My goal is not to provide broad generalizations but rather what Stake (1995) terms naturalistic generalizations, which are “conclusions

arrived through personal engagement in life's affairs or by vicarious experiences" (p. 85). My goal is to have my research resonate with practitioners in a way that they can, in turn, utilize this knowledge to assist their students.

Instead of reliability and validity, Lincoln and Guba (1986) argue for the trustworthiness of interpretations. Trustworthiness refers to the level at which the researcher's interpretations are substantiated. I want my audience to trust my purpose, research design and findings. I intend to accomplish this by triangulating my data and maintaining a chain of evidence. Trustworthiness of interpretations is also critical in teacher reflective practice (Hamilton et al., 2008) to protect against bias and to maintain strength in a study.

In order to triangulate data, researchers must present a "substantial body of uncontestable description" (Stake, 1995, p. 110). This involves looking at the same phenomenon through various lenses. I will also be employing the use of a critical friend (McNiff & Whitehead, 2010). This critical friend will be a fellow researcher who can review my research design and findings, and provide me with feedback. The critical friend helped me to correct for bias as well as to give another perspective on my research. Finally, I engaged in member checking. Stake (1995) argues that member checking can serve to triangulate data by adding additional interpretations. I allowed my participants to review their interview data and, in turn, re-evaluate the findings in light of their feedback.

Yin (2006) argues that using a chain of evidence can increase the reliability of a study. The chain of evidence is intended to allow for an external reader to draw the same



conclusions as the researcher. I planned to maintain a chain of evidence as follows: citing specific and sufficient data; staying true to the study design and protocol; linking research decisions regarding both design and findings back to the research questions; and being transparent by revealing all pertinent data and explaining its context.

The first and most obvious strength of this study is its thick description (Geertz, 1973). Since my students will be the participants, I have a prior relationship with them and thus be able to collect rich data. In addition, I am giving the reader an emic perspective of both students and a teacher. My research could also act as a model for other teacher-researchers who wish to conduct research in their own classrooms.

The study also has its concerns. As is common with practitioner inquiry, there is potential for bias. Conducting research in my own classroom has proven to be a challenge, but my organized research design along with my critical friend and member checking assisted in counteracting bias and easing this challenge.

### **Significance of Study**

The significance of this study lies in the insider perspective of developing and implementing Sci-YAR. First of all, Sci-YAR and other science curricula have not been thoroughly examined through an in-service teacher's perspective. The majority of studies on science curricula have been conducted by outside researchers (not the teachers themselves) and focuses on pre-service teachers.

Second, the power structures that exist in the science classroom have not been thoroughly examined as they relate to and can be altered by the incorporation of Sci-YAR's key features into the curriculum. Sci-YAR can increase student engagement and

participation. Critical theory promotes upsetting the status quo and in turn bringing about change in the classroom. Teaching and learning in a Sci-YAR classroom can not only change the experiences of the students and teacher, but can also challenge the traditional roles of students and teachers thus impacting the individuals involved inside and outside of the school setting.

Last, this study serves as a model for other science teachers to investigate their own teaching. Teacher voice is critical to education research and reform. Reflexive practice is also enhanced with support. This study intends to promote teacher-researchers to exercise their voice to better inform the research community about the realities of the K-12 science classroom. We as science educators are at a crossroads. Our understanding of how our students learn science is rapidly changing. The emic perspective gained through this study can help to further this discussion and our understanding of students' experiences in a K-12 science classroom. If we wish to truly uncover the realities of today's science classroom, we must place the teachers and their students at the center of our discussions and debates. This study can inspire teachers to place themselves and their practices at the center of their research, in turn, giving the science education community a clearer glimpse into what our teachers and students experience as a part of their daily realities called science teaching and learning.

## CHAPTER II

### LITERATURE REVIEW

#### **How Students Learn Science**

Science has a long history of being taught in ways that are incongruent with how students learn (National Research Council [NRC], 2007). According to Bransford and Donovan (2005), the most common approach to science teaching and learning is targeted at what scientists know, not what they actually do. Even the science education staple, *the Scientific Method*, which at first may seem to help students understand what scientists do, is actually inconsistent with how scientists go about their work and also with how students learn science (Bransford & Donovan, 2005; Windschitl, Thompson & Braaten, 2007). The Scientific Method supports the idea that scientific knowledge is constructed using a neat and orderly series of steps. Students often hold a distorted view of science because of the Scientific Method (Lederman, 1998). In reality, a sequence of steps that all investigations follow does not exist. This mythical series of steps can limit the view of scientific inquiry in the K-12 classroom setting (Lederman, 1998).

In actuality, science is messy. Science does not need to be neat, orderly or linear to be understood. Scientific discovery can result from a variety of approaches – experimentation, explanation, and observation, to name a few. For instance, astronomy must be understood using observations since celestial objects are too large and too distant to investigation using the Scientific Method (Windschitl et al., 2007). Scientists also need to be creative problem solvers in all aspects of their work from posing questions to

defining methodologies to analyzing findings to communicating understandings. The widely promoted, yet false perception that science is carefully and predictably conducted can marginalize the more imaginative free-spirited student (McComas, 1996).

The myth of the Scientific Method is just one example of how our understanding of good science teaching and learning has changed throughout history and will continue to change. The past century is filled with reform measures that reflect our ever-changing awareness of how students learn science (DeBoer, 2011). One of the most notable events in our history – the launch of the Soviet satellite *Sputnik* – increased the urgency for a change to the United States’ approach to science education. Many reforms were launched (no pun intended) in the 1950’s and 1960’s such as the National Education Defense Act and the National Science Foundation with the goal of increasing the number of American scientists in the work force (Bybee, 1995). Along with these reforms came heightened funding from the government which led to the development of many projects intended to support science achievement and student engagement in the areas of biology, chemistry, physics, and earth science at the high school level (Atkin & Black, 2007). These reforms emphasized basic science and relied heavily on direct instruction focusing on what scientists know as opposed to what scientists do (Yore, 2012). The idea of teaching science through the use of laboratory instruction was highly controversial during this time. While some organizations such as the Biological Science Curriculum Study supported the use of laboratory experiences to enhance science learning, the consensus was that this type of instruction was ineffective arguing that it took too much time and did not provide enough intellectual rigor (DeBoer, 2011).

The support for science education soon waned in the 1970's with events such as the lunar landing that placed the United States ahead of other nations in the area of science advancement. The United States was also enjoying an increase in scientists in the work force thanks to the reform efforts of the past two decades. Since the country was experiencing a boom in number and diversity of students in the public education system, the focus in education shifted from that of science achievement to that of better educating all students (Atkin & Black, 2007).

This movement for including all students changed our country's emphasis on science education reform to include a more learner centered approach. In 1993, Project 2061 and the American Association for the Advancement of Science released their benchmarks which outlined specific goals for inquiry and focused on students' habits of mind or students' critical thinking skills and their ability to do science, not just know science (Barrow, 2007). These benchmarks also attempted to stress new understandings how students actually learn science by increasing the frequency of laboratory experiences (Bybee, 1995).

Reforms have since moved away from the Sputnik era emphasis on producing American scientists and teaching basic science toward a more student focused approach with special attention given to science being inclusive and relevant to students' lives. We now understand that good science teaching and learning requires teachers to find out what students know and then challenge them to create meaningful understandings (Yore, 2012). This new awareness is evident in the National Research Council's *Framework for K-12 Science Education* released in 2012. The Framework along with the Next

Generation Science Standards argue that learning science is not just about mastering content knowledge but also includes developing the skills and practices to conduct scientific investigations. This approach to science teaching and learning focuses on the learners' construction of scientific knowledge and encourages a deeper understanding of scientific work (NRC, 2012).

These reform measures do not guarantee that change occurs at the classroom level. For example, telling students about science utilizing 300 page textbooks will not grant them deep understandings of science (Bransford & Donovan, 2005). Research has indicated that students learn science through the emphasis on theory, explanation and models (NRC, 2007) and not on the memorization of facts and the replication of controlled experiments. This more traditional approach to science teaching can result in students feeling excluded and disengaged from the science classroom. Emdin (2009) describes his experience of sitting in a science classroom in which he felt like an outsider. Emdin's experience acts as a foundation for his argument, that students who are labeled at risk struggle in the science classroom because the school culture is not compatible with, nor does it value, their individual culture.

For many students, the idea that they can positively engage in scientific investigations is new. Many students find science too difficult and view it as a topic only for those who are intellectually ready for this discipline (Emdin, 2010). Thus many feel unable to positively participate in science learning and disengage from the discipline.

This study examined an alternative to this traditional approach to science teaching, which focused on the inclusion and validation of students' ideas, beliefs and

experiences. I argue that incorporating the use of action research based projects and the positioning of students as experts into instruction not only has the potential to increase student engagement in science inside and outside of the classroom, but it also has the potential to positively impact the teacher facilitating the instruction as well.

### **Science Youth Action Research**

Science Youth Action Research (Sci-YAR) is a curricular framework and approach to instruction that is designed to engage students in action research and scientific inquiries that are connected to students' personal, local, or national issues (Coleman, 2014). Sci-YAR challenges students and teachers to rethink how science is defined in the science classroom. Science is more than a body of knowledge. Science represents a particular way of knowing that involves conducting investigations about the natural world; reasoning about evidence and forming conclusions; and evaluating knowledge claims (Lederman et al., 2002; Crowther et. al, 2005). Sci-YAR supports this definition of science. The inclusion of this definition and approach to teaching science as advocated by Sci-YAR is currently absent from many science classrooms (Lederman, 2007). Sci-YAR is that missing component in good science teaching and learning that could make science more accessible and meaningful to students. Sci-YAR is built on a foundation that all students can learn and do science if they are exposed to the understanding that science as a way of knowing and doing as well as how scientists really do science. This foundation and understanding of science are rooted in the research and theory of the nature of science.

## **The Nature of Science**

The nature of science refers to an epistemological understanding of what science is and how it works. Many organizations have taken to outlining specific elements of the nature of science with which students should be familiar. For instance, The American Association for the Advancement of Science [AAAS], (1989) argues that the nature of science includes the position that scientific knowledge should be accessible to all students and that scientific ideas are robust, but tentative. Thus, some scientific matters cannot be absolutely proven. No one set of steps exists for conducting scientific inquiry; however certain principles and skills do exist which will be discussed later in this chapter. The nature of science is a framework that helped to inspire the Sci-YAR curriculum.

As evidenced by AAAS's charge and the development of Sci-YAR, there is a movement to incorporate the understanding of nature of science into science curriculum. Lederman (1998) warns that this is not a simple task. He argues that teachers just emphasizing the nature of science will not prove any change in student learning. Rather, the nature of science must be explicitly taught. For instance, teachers cannot simply incorporate creativity into their instruction but rather they must inform students that science requires creativity and then provide instruction that allows students to experience how scientists use creativity. Teachers need to engage students in a reflection about the aspects of the nature of science after each investigation. For instance, Lederman (1998) offers the example *Real Fossils Real Science* which focuses on the nature of science guiding principle that science is a human endeavor and thus is dependent upon human imagination. In this lesson, the students are given fossil fragments with which they are to



trace and diagram on construction paper. Then the students draw the organism around the fossil diagram from which they believe the fossil came. The students will undoubtedly have illustrated different organisms utilizing different methods despite starting with similar fossil fragments. At the end of the lesson, the teachers explicitly state that this technique is exactly what paleobiologists use. The key to this type of investigation is the scientists' creativity and the acceptance of varied perspectives, evidence-based conclusions and sound methods.

The importance of student understanding the nature of science is not just illustrated through the above examples; it is also evident in the National Science Teachers' Association (NSTA) and their position statement regarding the nature of science. The statement not only supports an emphasis of the nature of science instruction in the classroom, but it also deconstructs the topic of the nature of science outlining tenets including (a) scientific knowledge is simultaneously reliable and tentative, (b) no single universal step-by-step scientific method captures the complexity of doing science, (c) creativity is a vital ingredient in the production of scientific knowledge, and (d) the social and cultural context of the researcher/observer impacts his/her experiences and expectations (NSTA, 2000).

The nature of science recognizes the ever changing and human aspect to science; it also values individual learners and encourages multiple interpretations of observations. It encourages students to be creative with their thinking and stresses that science is not absolute. It is subject to change. Sci-YAR incorporates the tenets of nature of science in

order to provide meaningful science learning experiences and to assist students in gaining a greater awareness of what science is and how science works.

Lederman (2007) argues that people do not possess adequate views on the nature of science. He states that the nature of scientific knowledge is (a) subject to change, (b) empirically based, (c) subjective, (d) involves human interface, imagination and creativity, and (e) socially and culturally embedded. These tenets are best illustrated by contrasting them with the misunderstandings often experienced in the science classroom. First, the nature of scientific knowledge is tentative or subject to change. Scientific understandings often change in the light of new evidence (Johnston & Southerland, 2001) brought about many times by advances in theory or technology (Lederman, 2007). Science does not provide absolute proof (McComas, 1998). For instance, scientists are unable to agree on one single theory of gravity. This is rarely explained in high school science courses. Complicating the issue of tentativeness is that many students do not fully understand what the tentativeness of science means. They will agree that it is tentative and subject to change, but cannot give clear definitions or descriptions of what is meant by “tentative”. Students need more background in understanding what is meant by this complex construct (Johnston & Southerland, 2001). Sci-YAR is designed to help students understand tentativeness as they explore the tentativeness of their own research and what makes for a strong argument.

Second, scientific knowledge is empirically based or based on observations of the natural world. As stated earlier, the Scientific Method is not an accurate indication of how students learn or how scientists do science. Many of the most notable scientific

discoveries in the past centuries did not use the Scientific Method, but rather relied on detailed observations. Copernicus and Kepler's research was qualitative and observation-based, as was the work of Charles Darwin. Darwin used non-experimental techniques to record his observations (McComas, 1998) and engage in theory building.

In addition, scientific knowledge is subjective and thus involves personal background and bias. Scientists' beliefs, commitments, experiences, and personal knowledge impact the way in which they view the world (Lederman, 2007). Scientists hold preconceived notions of how the world works (McComas, 1998). For instance, scientists in the early 20<sup>th</sup> century did not want to accept that the Earth's crust was comprised of individual moving plates because it was such a radical idea at the time. It was not until the 1960's when Alfred Wegener's continental drift theory of plate tectonics was widely accepted.

The nature of science also involves human interface. Many scientific problems are too complex for one individual to research thus most scientific discoveries are done in community (McComas, 1998). Scientific ideas need to be shared and then validated by other scientists. Because the scientific knowledge is dependent upon human interaction, it is therefore inherently socially and culturally embedded. Science is impacted by socio-economic, cultural and political factors. For instance, the practice of acupuncture was not accepted by Western society until Western science could provide explanations for its success (Lederman, 2007). Science is a human activity and just as humans are impacted by socio-cultural norms and practices, so are their scientific understandings and endeavors (McComas, 1998).

Last, the nature of science involves imagination and creativity. Science is not a neat and orderly endeavor (Lederman, 2007). Science is often taught in school through laboratory experiments consisting of a step by step procedure in which the teacher already knows the predicted outcome. If the students follow the procedure then they will get the right answer, and if not then they will be wrong (McComas, 1998). This approach is not only dry and uninteresting but inaccurate as to how scientists actually conduct scientific investigations.

The nature of science tenets inspired the development of Sci-YAR. Sci-YAR is comprised of five key features in which students are challenged to (a) collaborate through collective research, (b) conduct research that is student-led and student-generated, (c) participate in relevant science through action research, (d) engage in extensive personal reflection, and (e) use science as a way of knowing and taking action (Coleman, 2014). These key features are interconnected with the tenets of the nature of science as illustrated by Table 1 below. The nature of science tenets and the supporting research have informed and continue to inform the development and implementation of Sci-YAR. Additionally, the NGSS helped to shape the construction of Sci-YAR. The science and engineering practice that best corresponds with Sci-YAR's key feature is included in the left hand column.

Table 1

*Sci-YAR Key Features and Nature of Science Tenets*

Sci-YAR Key Feature	Corresponding Nature of Science Tenet(s)	Connection	NGSS Science and Engineering Practices
Collaborating through collective research	Science involves human interface	Both concepts value the importance of students working together in order to increase students' understanding of scientific knowledge	8. Obtaining, evaluating, and communicating information
Conducting research that is student-generated and student-led	Science is subject to change  Science is socially and culturally embedded	Since the research is student led and generated, the research will reflect the social and cultural backgrounds of the students. Additionally, the students will uncover that their research will change over the course of the semester and is, like all scientific knowledge, not absolute but subject to change.	3. Planning and carrying out investigations
Participating in relevant science through action research	Science is empirically based  Science involves creativity and imagination	Action research will challenge students to use many scientific practices not just those of the Scientific Method increasing their awareness of the empirical nature of scientific inquiry. By engaging in action research, students will need to utilize their creativity and imagination in order to	6. Constructing explanations (for science) and designing solutions (for engineering)

		conduct their research.	
Engaging in extensive personal reflection	Science involves human interface, imagination and creativity	As the students reflect on their research and its process, students are challenged to view science as a human endeavor and the importance of creativity and imagination to the process.	7. Engaging in argument from evidence
Using science as a way of knowing and taking action	Science is particular way of knowing: scientists collect information through scientific investigations and then form evidenced – based conclusions	Coleman (2014) along with Crowther, Lederman & Lederman (2005), and Lederman, El-Khalick, Bell & Schwartz (2002) share similar descriptions of science and argue that this is the approach that students should be taking in the science classroom.	4. Analyzing and interpreting data

According to Lederman et al. (2002), many students are not exposed to the perceptions of science detailed above, potentially leaving them with the feeling that their understandings of science are not valuable. In actuality, science is a socio-cultural construct, meaning that scientific knowledge can emerge from different interpretations of data. These different interpretations of data support the notion that scientific phenomena can be viewed with multiple lenses, which in turn suggests that science should be accessible to all students. I argue that science should be accessible to all students, but unfortunately currently it is not. Many barriers exist in science classrooms that prevent students from engaging fully in authentic science learning. The major obstacles to science accessibility are student misconceptions, teacher misconceptions, and the traditional role of teacher in a science classroom.

## **Student Misconceptions**

The reality is that what science is and how it works is absent from many science classrooms. This can result in students having limited understandings of the construction of scientific knowledge as well as difficulty connecting science to their own lived experiences. Understanding what science is and connecting science to one's life is vital to making scientific knowledge more interesting and accessible to students especially those who have been marginalized by science education. In Bianchini's (1997) study, she found that despite the teacher's insistence that every student could succeed in science, many students still viewed the higher achievers as the ones more likely to have greater access to scientific knowledge. Bianchini (1997) observed that while working in groups in a structured setting with carefully designed lessons and groups, students' unequal participation in group discussions remained. In this case, the students held on to traditional views of intelligence which was attributed to the students having varied past experiences with school science.

Schwartz (2007) has made explicit teaching the nature of science in her classroom a priority. She argues that the cause for many student misconceptions is the words we as educators often use in the classroom without considering the implications. Schwartz refers to words such as prove, truth, correct or incorrect answers as dead words. These words support students' misconceptions that scientific knowledge is absolute, constant, and that a single right answer exists. For instance, students are commonly taught that science requires evidence. Schwartz's students, however, misconstrued evidence to mean data. Additionally, data is often perceived to be quantitative, proof, or "the answer." In

actuality evidence is an interpretation of data and different students can interpret data differently supporting Sci-YAR foundation that scientific knowledge is not absolute.

### **Teacher Misconceptions**

These student misconceptions can be attributed in part to teachers also having a limited understanding of the construction of scientific knowledge. For instance, Morrison, Rabb, and Ingram (2007) conducted a study to explore teachers' views about science and on science instruction. This study included engaging teachers in reflective instruction on science and discussions about science with scientists, as well as exposing teachers to the practices, techniques and collaborations fundamental to scientific research. This research found that secondary teachers with prior experiences similar to this professional development did not change their views, however elementary and middle school teachers without these prior experiences did increase their knowledge of how scientists really do science. The factors that most impacted teachers' views the most were one-on-one interviews teachers held with scientists, job shadowing, and reflective instruction.

Lederman (2007) agrees with the above research findings. He states that teachers' conceptions of science are not automatically translated into practice. Teachers do not regard the construction of scientific knowledge as an instructional outcome equal to that of subject matter outcomes. In his historical overview of science instruction, he reiterates that teachers do not have adequate views or attitudes toward scientific knowledge. He cites a study by Rubba and Anderson (1978) that states the most effective teachers were typified by frequent inquiry orientated questioning, active participation by



students in problem solving activities, frequent teacher-student interactions, infrequent use of independent seat work, and little emphasis on rote memory and recall. This study illustrates that over thirty years ago, it was uncovered that the most effective science teaching was one that engaged and challenged students through problem solving just as proponents of instruction that emphasizes understandings about the nature of science and of Sci-YAR would argue; however, as Lederman (2007) states, the construction of scientific knowledge is still not adequately and thoroughly guiding instruction taught in many science classrooms.

One interesting component to the body of research pertaining to teachers and their understandings about the construction scientific knowledge is that it focuses largely focuses on pre-service teachers (Abd-El-Kalick & Akerson, 2004; Bell, Lederman, & Abd-El.Kalick, 2000; Shapiro, 1996; Schwartz, Lederman, & Crawford, 2004). The studies that do include in-service teachers are conducted by outsider researchers who offer teachers professional development and then investigate how their practice changes (Akindehen, 1998; Carey & Strauss, 1970; Scharmann & Harris, 1992). The emic perspective of the teacher who is engaging his or her students in instruction on the nature of science tenets and Sci-YAR is largely absent. Introducing a new approach to science teaching and learning requires risk taking and thoughtful planning which can only be truly understood through the perspective of a teacher making these changes. This insider's account of teaching can offer insight to its ability to transform the teacher's understanding of science, science teaching, and her impact on students' understanding of science and scientific inquiry.

### **Teacher as Facilitator**

If science teaching and learning are to become more accessible and meaningful to all students, a change must occur in the science classroom. This change requires a restructuring of the role of student and teacher. For instance, the role of teacher in the science classroom has acted as a barrier to students developing accurate understandings of how scientific knowledge is constructed (Bransford & Donovan, 2005). To help students with this understanding, teachers need to be attuned to their students' ideas and thinking (Bransford & Donovan, 2005). This requires teachers to shift their role in the nature of science classroom. McComas (1998) offers insight into this changing role. He argues that research conducted in the 1950s and 60s showed that science teaching was imparting facts to students with little attention paid to processes. Many teachers also assumed that scientists had specific personal characteristics that allowed them to participate in science using the Scientific Method. This indicates that the way in which scientific knowledge is constructed was not properly understood or taught in classrooms. The 70s, 80s and 90s brought about studies with results that were just as bleak. Many teachers in these decades were unaware of the socio-cultural components of scientific knowledge and did not include them into their instruction because they just did not understand it (McComas, 1998). In order to assist students in gaining greater understandings of how scientists actually do science, the teacher must abandon the more traditional lecture approach imparting facts of instructional methods and assume the role of guide as students uncover scientific knowledge for themselves (NRC, 2000).

Crawford (2000) agrees with re-thinking teachers' roles in science classrooms. In her yearlong study of a biology teacher who successfully designed and implemented an inquiry based curriculum, she found that the teacher had greater success when he challenged his students to revise their own understanding of science in the context of their own lives. In order to assist his students in this process, this teacher situated the content in real life situations; allowed the students to grapple with data; fostered collaboration between student and teacher; connected students with community; modeled behaviors of a scientist; and fostered ownership by students. Most significantly, Crawford found that the teacher needed to assume multiple roles in his instruction. No longer was he the keeper and giver of knowledge. Rather he needed to reposition himself as motivator, guide, mentor, and learner.

### **Students as Experts**

When teachers alter their roles in the classroom from all knowing keeper of knowledge to facilitator of students uncovering knowledge, their students' roles in the classroom shifts as well (Barton & Tan, 2010). In the Sci-YAR classroom where multiple interpretations of knowledge are accepted and valued, students are given the opportunity to become the experts. They are allowed to use their creativity and imagination to provide evidence and support conclusions related to their observations.

Traditionally, science education has focused on formal epistemologies or how much do students know about professional science – the work that scientists have done or are currently doing. Sandoval (2005) argues that in order to make science teaching and learning more meaningful to the students we must focus on students' practical

epistemologies. These practical epistemologies focus on what students know about their own scientific knowledge as opposed to what students know about someone else's knowledge. The practical epistemology approach also places value on students' localized knowledge and allows them to build on what they already know. In this case, the students' work is grounded in what they know, not what someone else knows thus increasing the likelihood of a true transformative experience and enduring understandings (Sandoval, 2005).

Sci-YAR is grounded in Lederman's (2007) tenets of the nature of science, but also focuses on the practical epistemologies of students by positioning them as experts in the classroom. The curriculum and is in large part inspired by the work of Brice Heath (1983), whose research focused on action research and positioning her students as scientists and as experts. In one of her most popular ethnographies, Brice Heath told the story of students in a lower income Black community she titled Trackton. The students she highlighted were fifth-grade boys who struggled with many subjects – in particular science. The students were given an assignment to determine which crops grew the best in their community. The boys were positioned as the experts. They were made responsible for generating the question, methods, data collection, and the conclusion. By giving the students control and ownership of their science learning, the Trackton boys' achievement in all subjects increased. "The [research] experiences of the students had enabled them to focus their attention on a variety of features of knowledge and information collected in their own communities and in their personal repertoires" (p.

326). By positioning students as experts, opportunities become available for science to be empowering.

Facilitating empowering and transformative science experiences can be a reality. According to Pugh (2002), a transformative experience is marked by the active use of a concept that leads to an expansion of perception and of value. Transformative teaching includes the artistic crafting of content and the scaffolding of perception and value by creating learning communities in which all students participate. The power to inspire action and transform perception is unfortunately not widely seen in science classrooms today, but it can transform a teacher's experience as well as that of his or her students' experiences.

Transformative experiences can be facilitated through positioning students as experts. Fielding (2001) states that by positioning students as researchers the dynamic between student and teachers shifts. This shift requires both students and teachers to form a partnership in which both parties share the responsibility for students' learning. This partnership, which Fielding calls a dialogic learning community, can positively impact both student and teacher.

In addition, the positioning of students as experts in the classroom requires a strengthening of student voice. Jenkins (2006) conducted a comprehensive study regarding the role of student voice in science education. He reviewed many previous studies in an attempt to determine what students think about their science education. Jenkins found that the majority of students have a strong desire to learn science and view science as an important subject that will play a significant role in their lives now and in

the future. He also found that most students felt overloaded with content and struggled to find the relevance with science content to their daily lives. Students also expressed a strong aversion to such classroom activities as taking notes, repetition of activities (for example, cookbook type lab exercises), and reading text books. Lastly Jenkins found that by listening to students and their views on science teaching and learning, students can experience increased motivation and engagement in the science classroom.

Positioning students as experts and as researchers is a critical aspect of Sci-YAR. Students are in control of selecting their research topics, questions, methodologies, analysis techniques and how they organize and present their findings. In Sci-YAR, the teacher is the guide and the students and their ideas are the focus of instruction. This allows for students to make decisions similar to the work of scientists, thus making them, not the teachers, the experts.

While giving students' choices in the classroom can be overwhelming and intimidating at first, it will lead to richer and more fulfilling learning experiences for both student and teacher. What is meaningful to one student might not be the case for another. Thus the teacher needs to be able to be flexible with his or her instruction and have an understanding of the contexts in which the students derive their understandings of science (NRC, 2007). By changing the roles of teacher to facilitator and student to expert, the power dynamic of the classroom is also altered. This rethinking of science education demands a rethinking of the power structures present in the classroom. Critical theory can help to challenge the traditional approaches to science teaching and act as a foundation to facilitate change.

### **Theoretical Framework**

Critical theory can be defined as a lens by which issues of power, justice, race, class, gender and ideologies interact with social institutions to create a cohesive social system (Kincheloe & McLaren, 2003). Critical theory has questioned the presumption made by many countries, including the United States that its citizens are free and capable of fully participating in its democratic society. In reality, according to the critical theorists, not every U.S. citizen is entirely free (Kincheloe & McLaren, 2003). In fact many people experience marginalization based on differences in economics, race, gender, sexual orientation, education, or religion. This power struggle can and does alter people's views of themselves and their world. This view of self is highly influenced by social and historical factors (Kincheloe & McLaren, 2003). The purpose of the critical theorists rests in their ability to disrupt and challenge the status quo (Kincheloe & McLaren, 2003). Many critical theorists such as Henry Giroux argue that the goal of education is to prepare its students with the emancipatory tools to radically shift this power paradigm (Giroux, 1997).

Power structures exist in science classrooms, whether in the notion that teachers are the one who possess the knowledge or that science is reserved for only the highly intelligent. These power structures shape students' social interactions which in turn impact their learning (Barton & Tan, 2010). By positioning the students as researchers and as experts in the classroom the traditional role that students have played in education as well as the power structures of the classroom will be challenged. I am using a critical theory lens to conduct my research in order to further investigate how these power

structures impact students' reactions to Sci-YAR. I will also use critical theory to examine issues of power, justice, race, economics and class associated with re-positioning the students as researchers.

### **Power Structures within the Science Classroom**

The social system of a school is in actuality constructed by the values, beliefs, experiences and backgrounds of the individuals, both children and adults, who are served, and serve, within the institution. According to Pinar (1992), schools function to reproduce the class structure of the workplace. Thus the ideas and values of the dominant class are imposed upon the school to become the ideals and values of the school regardless if they represent the ideals and values of the individuals. In addition, Pinar (2004) argues that curriculum research and development is a political endeavor. The goal of education should be to liberate the oppressed. In order to accomplish this task, however, a fundamental change in our culture is needed.

According to Kincheloe and McLaren (2003) critical theory offers educators a way in which to free their work from the forms of power that are present in schools and in science classrooms. Giroux (1988) argues that schools are currently institutions designed to keep students subordinate to values of the ruling class. However, this not need be the case. In fact, schools can be places where students are educated to challenge these norms and it in turn become empowered.

The power structures extend into the classroom. According to Giroux (1997), teaching has been centered on a more positivist, teacher-centered approach to education. In this case, knowledge is objective. In the science classroom, this means that science is



presented as an external body of knowledge that students must work at to acquire. This body of knowledge is static and free of context. Thus, students' abilities to understand and to participate productively in science rest in the teacher dropping pieces of this external body of knowledge into the brains of the students.

Apple (2004) adds that these power differentials are greatly increased by what he explains as the de-skilling of teachers by those in charge – for instance administrators or school boards. He claims that teachers' workloads have increased but their control over the quality of the work and their participation in decision making regarding the work have declined. In order to minimize the impact of power structures on students, Apple insists that teachers be granted more control over the curriculum in order to reduce the separation of the conception of instruction from its execution.

According to Emdin (2010), science is viewed as a discipline only for a select few – those who are better at school or are perceived as better students. Science textbooks further exacerbate this problem. Most textbooks are over 300 pages and are full of complicated diagrams and inaccessible language. Many students feel powerless in the science classroom. In addition, students are often forced to conduct basic experiments in which students blindly follow a list of steps. These power structures shape students' social interactions which in turn impact their learning (Barton & Tan, 2010).

According to Freire (1970), teaching is often viewed as the act of depositing information into students' minds. In the case of the science classroom, this takes the form of repeating concepts and reenacting experiments. This perpetuates the misconception that one correct answer exists. Science teaching, if taken from the

approach that learning is a cultural process, can value each student's interpretation of data and supporting the philosophy that multiple correct answers exist, thus making science truly accessible for all students.

Science education has traditionally supported the values of the middle class, however we educate more than just the middle class. According to Barton and Yang (2000), even in today's society, those in the media who are portrayed as being scientists are White males. Despite the growing popularity for inquiry based and student centered instruction, many science teachers still have traditional views on the construction of scientific knowledge. Science education still supports a single view of science that is situated in White middle class values. Thus students associated with White middle class values can feel excluded. The reliance on the Scientific Method also supports the notion that one correct answer exists which reflects back to Giroux's (1997) supposition that knowledge is viewed as an external body of knowledge. Students who feel intimidated by science will feel even further removed from science if they internalize the idea that only one correct answer exists. Critical theory will undergird my research as I investigate the following questions.

1. How has my teaching changed over the past four years?
2. How do I make meaning of my experience engaging in the Sci-YAR curriculum?
  - a. What am I learning about myself as a teacher and my students when they experience Sci-YAR instruction?
  - b. What are my reactions while engaging my students in Sci-YAR?

- c. How does teaching Sci-YAR affect other areas of my life?
- 3. How do my students make meaning of their experiences while engaging in the Sci-YAR curriculum?
  - a. What are my students learning about themselves when they experience Sci-YAR instruction?
  - b. What are my students' reactions to Sci-YAR?
  - c. How does Sci-YAR affect other areas of my students' lives?
- 4. How does engaging in Sci-YAR impact me and my practice as I move forward in my career?

In this study, critical theory allowed me to challenge the power dynamics of my classroom in a number of ways. First, Sci-YAR is a non-traditional approach to science teaching at my school. By framing my study around Sci-YAR, I was able to examine the impact of making science more accessible to my students. Second, I investigated these power structures by placing myself at the center of my research. Not only did I research my students' reactions to Sci-YAR, but mine as their teacher as well. This allowed me to study my role in these power structures in hopes of minimizing them in the future. Last, my research challenged me to strengthen my students' voices. It is a rare occasion in which students are asked for input regarding their learning experiences. By giving them the space and the safety for honest and open feedback, it was my intention to better understand their reality of being in my classroom – power differentials and all.

Critical theory will not only guide my research, but it will guide my instruction as well. This curriculum is intended to disrupt the power dynamic in my classroom.

Traditionally, the teacher is perceived to be the keeper of knowledge; in order to learn and be successful in the science classroom, the students must receive information from the teacher (Friere, 1970). In contrast, my curriculum positions the students as the experts and the teacher as the facilitator. Students were challenged to become empowered through their Sci-YAR investigations and the corresponding meaningful science learning experiences.

## CHAPTER III

### METHODOLOGY

#### **The Sci-YAR Curriculum**

A few years into my science teaching career, I noticed that my students left my classroom in June with many of the same misconceptions they had upon walking into my classroom for the first time in August. I grew tired of using the same traditional instructional methods as well as holding my traditional position as keeper of knowledge. Three years ago, I decided to change my approach and my curriculum. Along with Elizabeth Coleman, a colleague from Loyola University Chicago, we developed an action research-based science curriculum now known as Sci-YAR. This curriculum challenges students to work in groups to identify issues in their communities, pose investigable questions of interest to them, and then conduct action research in order to better understand the issues and propose possible solutions. During this time, students also document and analyze their personal experiences and practices of science. All components of the action research projects are shared publically in a culminating research symposium. The curriculum consists of four units which are (a) selecting a research topic, (b) developing a research plan, (c) collecting and analyzing data, and (d) formulating findings, sharing results, and taking future action. The action research projects are conducted over the course of approximately six months, primarily during the second semester of my freshman biology course. As Table 2 illustrates, Sci-YAR is taught concurrently with content typical of a high school Biology course.

Table 2

*Example of an Actual Month's Lessons during Sci-YAR*

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1	<b>Journal entry #4 &amp; Introduction to Claims-Evidence-Reasoning Framework</b>	<b>Game: Back that Claim Up &amp; Review research questions</b>	Wordsplash & work on vascular system chart	Finish and review vascular system chart	Quiz & set up for transpiration lab
2	Run transpiration lab Homework: complete reading guide	Graph & analyze transpiration lab data	<b>Journal entry #5 &amp; Finalize research questions</b>	<b>Review definition of data &amp; begin data matrices</b>	Begin work on plant's reproduction cycle chart
3	Finish and review reproduction chart	Begin reproduction cycle activity	<b>Finish data matrices &amp; work on self-documentation</b>	<b>Work on research plans</b>	Finish reproduction activity & Begin test review
4	Plant Kingdom Test review	Plant Kingdom Test	<b>Finish research plans</b>	<b>Present research plans</b>	<b>Present research plans</b>

*Note.* Indicates Sci-YAR activity.

The Sci-YAR curriculum and instructional framework are significantly different from open inquiry. In open inquiry, teachers usually select the topic and the students then determine the question, procedure, and solution (Banchi & Bell, 2008). In my classroom, however, my students select topics in addition to questions, procedures, and solutions. I assist students through the process of selecting topics that are important to them, thus ensuring that the topics selected will be connected to the students' lived experiences and in turn tap into their social and cultural knowledge.

Another significant component to the students' research projects is reflection. Reflection allows for the students to keep records of their knowledge of science and to hopefully validate their multiple interpretations of this knowledge. Reflection also encourages students to document how their ideas change over time which increases their awareness of how scientific knowledge is constructed. This awareness can lead to enduring understandings (Michaels et al., 2007). In addition, reflection is an important component of action research. Action research challenges students to better understand their positive roles within their socio-cultural context (Kemmis & McTaggart, 2000). Reflecting on their specific experiences with their research will also give students greater insight into themselves as researchers and as experts. These insights can be emancipatory and can help my students to understand how their ideas and actions can positively impact their homes, schools, and communities (Carr & Kemmis, 1986).

### **Setting**

This study took place in my classroom at an all-boys Catholic school in the city of Chicago. The school is tuition-based with a college preparatory curriculum, and over 90% of our students attend college after graduation. The student body is comprised of approximately 70% of students who identify as White; 20% who identify as Black; and 8% who identify as Latino. My students represent a wide range of socio-economic backgrounds. Biology is a required course and is comprised of freshmen and sophomores.

The study had a dual focus on a) my students' reactions to and experiences with Sci- YAR both inside and outside the classroom, as demonstrated through interviews, and b) my reactions and experiences as I engage my students in the Sci-YAR curriculum.

### **Research Design**

The purpose of this study was to investigate how my students and I make meaning of our experiences as we engage together in Sci-YAR. In doing so, I attempted to not only to give my students voice, but to give teachers a voice as well. In order to accomplish this task, my study was two-fold. First, I conducted a self-study on my experiences as I engaged my students in Sci-YAR. Second, I conducted a phenomenological study on my students as they make meaning of their experiences as they participate in the Sci-YAR curriculum. My intention was that through this process, my research will not only make science more engaging to my students, but transform me as a teacher of science as well.

### **Self-Study**

Self-study allows for practitioners to examine and to improve their own teaching (Pine, 2009). It supports the idea that we, as teachers, have a responsibility to assess our progress in the classroom, uncover inconsistencies between our practices and beliefs, and to challenge our thinking (LaBoskey, 2004). Self-study is also aimed at improvement with particular attention given to transforming teachers as a means to facilitate student transformation (LaBoskey, 2004).

Bullough and Pinnegar (2001), argue that goal of self-study is not to just acquire knowledge but to “provoke, challenge and illuminate” (p. 20) our practices as teachers as



well. They state that self-study is a methodology that is initiated by and focused on teachers as we relate to our instruction and to our students. In addition, they give guidelines for conducting rigorous self-study. Autobiographical self-studies should (a) ring true and enable connections, (b) promote insight and interpretation, (c) engage history forthrightly through the author's honesty, (d) center on the issues that make someone an educator, (e) be told in an authentic voice, (f) aim to improve learning for oneself and others, (g) focus on something genuine, (h) attend to persons in settings, and (i) offer fresh perspectives (Bullough & Pinnegar, 2001).

My self-study was conducted with the goal of better understanding my experiences as I engaged my students in the Sci-YAR curriculum. Specifically, I intended to challenge myself to transform my teaching to make science more accessible and engaging for my students. Self-study can facilitate this type of transformation through the type of inquiry that allows for teachers to closely examine their practices and beliefs. Another goal of my self-study was to strengthen my voice as a classroom teacher. I intended to accomplish this by gaining a deeper awareness of how I am connecting with my students through my instruction, and also by sharing my experiences with interested readers. Last, this self-study highlights my reactions to Sci-YAR as well as the knowledge I gained from working with my students, and helped me to uncover how teaching Sci-YAR extends to other areas of my life outside the classroom.

**Procedures for data collection.** With regards to my self-study, I kept a written journal as well as took audio recordings of my weekly reflections. For the written journal reflections, I used a combination of pre-determined prompts as well as open-ended

writing on my experiences inside and outside the classroom (see Appendix A for a list of journal prompts). In addition I conducted a content analysis of my science curriculum from before Sci-YAR's inception five years ago to this past spring of 2014. The content analysis protocol was designed using the seven tenets of Sci-YAR as outlined by Coleman (2014). This content analysis protocol was summarized in a checklist that allows for comments on each of the seven tenets (see Appendix B for protocol) and was used to inform my audio and written journal entries. Data collection for the self-study began in January of 2014 and continued until late August (see Appendix C for a complete data collection timeline).

### **Phenomenological Study**

Phenomenology is a methodology in which the researcher investigates a certain event or phenomenon through the eyes of the individuals or those who experienced it. The goal is to understand lived experiences and to uncover how individuals make meaning of their experiences (Creswell, 2009). At the center of phenomenology are peoples' realities. The researcher cannot be separated from his or her realities, beliefs, and values. Phenomenology accepts and supports this subjective approach to research (Groenewald, 2004). In addition, phenomenology questions how the world works. Phenomenologists "thrust toward the world not away from it" (Greene, 1973, p. 131). In other words, phenomenological researchers gravitate towards the complex nature of how individuals make meaning of their realities and attempt to enter individuals' lives in order to better understand their realities. In the case of this study, the focus will be on my students' realities of engaging in Sci-YAR. The researcher's goal is to focus on how the

social world is made meaningful and how people experience objects in the social world. People approach life with knowledge constructed from their unique perspectives. These beliefs, values, and attitudes are then applied to experiences thus making them meaningful (Holstein & Gubrium, 2005).

Phenomenology has specific implications for classroom teaching as well. Phenomenology asks the question, what is it like to have a certain experience? It helps us as educators investigate the question of whether we really know what it is like to be a student. This question guides my research. Investigation of knowledge brings us back to who we are in our lives and in our worlds (Van Manen, 1982). This phenomenological study intended to uncover the ways in which engaging in Sci-YAR connects to my students' lived experiences. Through this process, I was able to view my classroom through the perspective of my students with the goal of better understanding the ways in which I can better serve my students. By understanding my students' lived experiences in my classroom, I can better understand my own experiences and their teacher.

The phenomenon I will be researching in this study is the Sci-YAR curriculum, and I will be investigating students' lived experiences after they engaged in this phenomenon. This curriculum – which positions students as experts, allows them to make decisions regarding what they learn, and explicitly engages them in meaningful reflection – is not taught in any other classroom at my school or in any other school in Chicago, which indicates that this is a unique phenomenon worthy of researching. Through this phenomenological study I also investigated the ways in which my students

engaged in Sci-YAR, their reactions to Sci-YAR, and how Sci-YAR affected other areas of my students' lives.

**Procedures for data collection.** In terms of the phenomenological study, the data was drawn from interviews with the students, the students' written journal reflections (see Appendix D for a list of student journal prompts) and a content analysis of the student's final research projects. The content analysis protocol used for the students' final projects was again based on Coleman's (2014) seven key features of Sci-YAR, and was similar to the protocol used in my self-study (again, see Appendix B for sample protocol). The content analysis was used to inform my interview questions.

The interviews consisted of three separate conversations each lasting forty minutes to an hour. They were all conducted at the students' homes, at school or at a location of the students' choosing. This approach to conducting interviews is based on Seidman's (2006) guidelines for phenomenological interviews. The interviews occurred four to seven days apart and were structured in the following manner. The first interview focused on the students' life histories with particular attention paid to previous school and science experiences. The second interview asked the students to recount the details of their experiences as they engaged in Sci-YAR. The third and final interview allowed the students to reflect on the meaning of these experiences. The interview questions were informed by Sci-YAR's theoretical framework and design, but were only a foundation and a guide for my interview questions. In addition I generated specific questions that focused on the students' experiences in my classroom based on their journals and action research projects (see Appendix E for interview protocol). Member checking occurred

during the interviews and was based on my reflections of the previous interviews.

Member checking is a process by which the researcher shows the participants his or her interpretations of their interview data and asks for feedback in order to ensure that the participant is accurately represented (Stake, 1995).

The interviews were audio recorded. A few notes were taken, but not many as a way to minimize the power dynamic and to make each interview more relaxed and conversational. I was concerned that if I were to take extensive notes while students were talking, they may feel overly self-conscious of their word choice and feel uncomfortable sharing their opinions frankly. I also allowed my students and their families to select the locations of each interview as another attempt to correct for the power dynamic that exists between teacher and student.

One major way in which I minimized this power dynamic was by thoughtful timing of this study. The interviews took place over summer break from June 2014 to August 2014 after the biology course concluded and grades were submitted. The analysis of my students' work and journals occurred at this time as well. By conducting the phenomenological study in the summer, I reduced the pressure and discomfort students might feel when being interviewed by their former teacher. I will no longer be in a position to assign grades over the summer, and I did not have these students in class the following school year (again, see Appendix C for complete timeline).

**Participants.** With regards to sampling for the phenomenological study, I opened the study to all students in my two biology courses engaging in the Sci-YAR curriculum – approximately 60 students. Elizabeth Coleman recruited my students

during the spring semester while I was out of the classroom. She explained my study to my students, collected their consent and assent forms, and answered any questions from my students and their parents' projects (see Appendices F through J for copies of recruitment materials). The students submitted the signed consent and assent forms in a sealed envelope to Elizabeth who held them for me until final grades were submitted on June 2, 2014. Elizabeth then turned this information over to me, and it was only at this time did I have access to the forms and a list of my eight participants. This process ensured that my students would not feel as though their grade depended on their participation in my study.

My participants represented a wide range of backgrounds. Two students were from affluent neighborhoods, two were from more improvised neighborhoods and four lived in working class neighborhoods. Racially, two of my participants identified as Black (25%), two as Latino (25%), and four as White (50%). This is in contrast with the school's population identifying as 70% White; 30% Black and 8% Latino. However, the racial backgrounds of my participants are indicative of the students in my classroom since I teach many non-honors level track courses and our honors level courses are disproportionately comprised of students identifying as White. Table 3 outlines more information regarding my participants.

Table 3

*List of Student Participants*

Student Pseudonym	Research Focus	Significant Quotation
Keith	Astronomy	"I'm a man of time. I wanted stuff done."
Phil	Spiders	"If I build something or do something, I love to show it off. I love to be like, this is what we learned. I like to share information with people. I like to make people smarter."
David	ALS	"I'm good with helping people."
Peter	Drugs in the Community	"I would say I'm not the average student. I try to do well in school and I'm a chill person in school."
Andrew	Hockey Injuries	"I don't believe in myself sometimes as a leader because I goof off."
Jerome	Drugs in the Community	"Me being the African American young man, I feel that I have to act a certain way because people already look at me differently."
Michael	Steroids	"[I] don't trust other people's opinions always."
Bob	Hockey Injuries	"I think I'm quiet, maybe. I'm not that social. I just want to get the notes, do the work and try to get a good grade."

**Data Analysis**

The data collected allowed me to create a thick description of the Sci-YAR curriculum generated from a multitude of sources (Geertz, 1973). This allowed me to

assess my reaction as well as my students' reactions to Sci-YAR instruction. Thick descriptions were necessary for this study because they provide more "detail, context, emotions, and the webs of social interactions that join persons to one another" (Denzin, 1989, p. 83). Participant voice was highly valued in this study. In order to maintain the integrity of my participants' voices, I conducted member checks often throughout the interviews and used multiple methods of analysis by which to secure their voices.

In terms of analysis, while the study itself has two distinct parts – the self-study and the phenomenological study – the studies could not be analyzed separately. Each aspect of one study informs the other. The data generated regarding my reactions to facilitating Sci-YAR instruction informed my perspective and analysis of my students' reactions to the curriculum, and likewise the students' reflections and feedback informed my perceptions and practices. Therefore, similar data analysis techniques were employed.

According to Corbin and Strauss (2008), data analysis is the task of interacting with data. I interacted with my data in a variety of ways including direct interpretation, pattern matching, and data explication. First of all, Stake (1995) argues that direct interpretation needs to be utilized in data analysis because the manner in which the researcher makes sense of a study is important. I organized my direct interpretation through the use of my audio recordings and written journal reflections including both the open-ended entries and those written around specific prompts. These entries allowed me to analyze my experiences throughout the curriculum implementation process. In addition, Stake (1995) suggests that researchers make use of the practice of memo writing



when analyzing data. These memos are similar to a journal entry in that they are a place for the researcher to express their experiences, frustrations, and successes. The difference is that in the analysis phase of research, these journal entries or memos act as a way for researchers to have conversations with their data. The memos could be centered on a specific theme that the researcher sees emerging with in the data. By structuring journal entries as memos, the researcher is better able to identify and to organize their data around emerging codes.

Second, Stake (1995) also suggests that data be analyzed by categorical aggregation or by grouping data into categories. I accomplished this task though pattern matching. In pattern matching, a basic pattern is compared with predicted emergent codes (Yin, 2009). In other words, the collected data is matched and then grouped according to pre-determined themes or codes (see Appendix K for a list of initial codes).

Last, Groenewald (2004) warns against the traditional analysis techniques of phenomenological data. He argues that analysis is dangerous for phenomenology because traditional methods suggest researchers break the data down further into smaller parts. By deconstructing the data in this manner, the researchers can lose sight of the phenomenon. Instead, Groenewald argues that phenomenologists should explicate the data or investigate the different sections of the data, but keep the context whole and therefore preserving the phenomenon. Hycner (1999) outlines a systematic approach to explicating phenomenological interview data including (a) bracketing or suspending the researcher's perspective in order to truly see the phenomenon from the participants' points of view, (b) reviewing the interview data while making note of every nuance in

order to gain an understanding of what the interviewee's meanings in his or her response, (c) grouping the meanings together to form preliminary themes, (d) summarizing the data and member checking, and (e) extracting the general themes from all of the interviews and then summarizing them in total.

## **Considerations**

### **Methodological**

The researcher can never be totally separated from his or her beliefs, values and experiences (Groenewald, 2004). Thus my challenge was to understand how I and my students' make meaning of our experiences and to describe our realities. Because I represented multiple realities in this study – those of me as a teacher, those of me as a researcher, and those of my students – I needed to be thoughtful and rigorous with my research. In order to maintain the quality and integrity of this study I took into account this study's trustworthiness, validity, and generalizability.

**Trustworthiness.** Merriam (1995) states that the trustworthiness of a study indicates how well a study does what it was designed to do. Yin's (2009) chain of evidence helped to ensure that this occurs. Yin argues that the chain of evidence is intended to allow an external reader to come to the same conclusions as the researcher beginning with the research questions and following through to the findings. The chain of evidence places the reader in the researcher's perspective and walks them through each step as if it was evidence presented in court.

Thomas (2011) agrees that an outside reader is a critical consideration when presenting research. Thomas states that the integrity of a study is dependent upon the

ability of the researcher to communicate their rationale of problem, defense of methods chosen, and relationship between the claims presented and the evidence collected. This integrity can be achieved by clarity in writing and sufficient information represented.

I maintained the trustworthiness of my study by using Yin's (2009) chain of evidence. I attempted to keep my writing clear and focused while placing my research questions at the center of my study. This was to ensure that all background information, methodologies used, data collected, and findings stemmed from these questions, thus allowing the reader to follow my rationale through to conclusions. In addition, I also kept in mind Thomas' (2011) charge for the researcher to effectively convey his or her message to the intended audience.

**Validity.** With regards to validity, I used what Cho and Trent (2006) call transformational validity. Transformational validity argues that research is an emancipatory process that leads people to change and in turn work toward social justice. In this case, validity is achieved through rigorous self-reflection on the part of the researcher. For instance, the researcher must consider the multiple perspectives represented in the research and then examine their meanings in order to gain greater awareness and understanding. I used transformational validity to guide my research, because I too contend that research should be emancipatory and lead to social change. My study is intended to re-consider the traditional approaches to science teaching and learning and to bring about change for both students and teacher in the process.

Cho and Trent (2006) argue that in transformational validity can be achieved through close examination of one's practice. Through my self-study, I examined myself

as teacher and through my researcher journal I examined myself as researcher. In addition, crucial focus was given in my reflections on how well my claims are supported by sufficient evidence. This allowed me to gain a greater perspective and understanding of my research.

With the exception of self-reflection, transformational validity does not have a set list of methods or techniques for achieving it. Therefore I used the work of Merriam (1995) to help inform my research's validity. Merriam offers guidelines on how to ensure validity in qualitative research. Merriam states that validity is the researcher's ability in describing someone else's perspective and experience. This can be accomplished by triangulating data, member checking, using a critical friend or friends to review research and provide feedback, and stating the researcher's previous experiences and potential biases before revealing research methods and outcomes.

As stated earlier, I focused on generating a thick description (Geertz, 1973) of my data. This thick description afforded me much data from which to extract meaning, to gain greater understanding of the multiple realities present, and to validate my findings. In addition, I engaged in reflection as Cho and Trent (2006) propose. Reflection will be a key aspect to the self-study, thus I also kept a researcher's journal. It provided me a space to record my reactions to interviewing my students and analyzing their work that is separate from the self-study data. Last, I also used Merriam's (1995) suggestions: collecting multiple forms of data, frequent member checking, use of peer collaboration and feedback and transparency with my history were all critical components of my research.

**Generalizability.** According to Merriam (1995), generalizability is not the goal with qualitative research. Rather the goal is to understand one situation in depth. Stake (1995) calls for naturalistic generalizations which encourages the reader to resonate with an aspect of the research. This is in contrast with other uses for generalizability, which call for findings about one study to hold true for larger populations. Stake argues that people have a greater opportunity to learn from naturalistic generalizations because the goal is to make the reader feel as though he or she is present in the study.

The challenge in my study was to provide the reader with vicarious experiences of my classroom either as a student, as a teacher, or as both. These allow the reader to connect with my research, thus creating the opportunity for naturalistic generalizations to be made. My intent was to make my writing clear but also to include what Stake (1995) calls vignettes or small stories that briefly describe the research and connect the reader to the setting, rationale, and/or participants. The vignettes originated from a multitude of sources such as: my audio-recording reflections, my researcher's journal, the students' interview responses, and the students' journals. The goal of using vignettes is to place student and teacher voice at the forefront of the research, thus making the reader feel as though he or she is present in my classroom.

### **Ethical**

Keeping with critical theory and its focus on freeing individuals from oppressive power structures (Kincheloe & McLaren, 2003), I conducted my research in my own classroom assuming dual roles – that of teacher and of researcher. The self-study component of my research gave me the opportunity to better understand my realities,

values and biases. By placing myself at the center of my research in my self-study, I was able to better consider the power structures that are present in my classroom and thus work to minimize them (Kincheloe & McLaren, 2005).

I acknowledge that my study includes both benefits and risks to my participants. Although, the benefits far outweigh the risks, I needed be aware of the risks and work to minimize them. One potential risk that I attended to is coercion. Cochran-Smith and Lytle (2009) warn that many might argue that assuming dual roles of teacher and research is unethical because students will be coerced either intentionally or unintentionally. I attempted to control for coercion by waiting until the semester is over, and grades have been submitted before beginning the interview process with my students. Cochran-Smith and Lytle argue that conducting research in one's own classroom just as I intended to do is an asset in that true emic perspective can only be gained through practitioner inquiry. Since this research allows the reader to gain an insider's account into my practice, it is therefore not a limitation. The overarching goal of practitioner inquiry is to challenge inequities and enhance learning for students which can only be achieved through the insider perspective (Cochran-Smith & Lytle, 2009).

I agree that while I needed to address issues such as coercion or the power dynamics that exist between student and teacher, I also argue that the benefits to this type of research are numerous. For instance, I was able to strengthen my curriculum and my teaching, and provide my students a vehicle by which their voices can be heard. Overall, by engaging practitioner inquiry, my practice has improved and thus my future students' experiences in my classroom will improve as well.

Just as I needed to control for potential coercion in my study, I also needed to control for researcher bias as well. In order to minimize researcher bias, Groenewald (2004) argues for the use of bracketing. As stated earlier, bracketing encourages the researcher to separate from his or her personal views or preconceptions. Thomas (2011) suggests that the key to dealing with potential bias is reflection. Thomas gives a series of questions that every researcher needs to ask him or herself. These questions include (a) who is this research benefiting? (b) do I have the right to take up people's time? (c) and what is the potential discomfort associated with this research? I used these questions as journal prompts for my researcher's journal. I asked myself these questions often throughout my study in order to increase awareness of my personal views or preconceptions and in turn ensure that they do not interfere with my research.

In order to account for the ethical considerations present in my study, I constructed a timeline to ensure the protection of my students. While I collected self-study data from January to August, I did not collect the phenomenological data until after the school year is over and final grades were submitted. Thus, the students' participation (or lack thereof) did not impact their grades in any way. I also used the bracketing techniques as outlined by Groenewald (2004) and the journal prompts suggested by Thomas (2011) to ensure that I stayed aware of my values and experiences in order to control for bias.

As stated earlier I assumed dual roles as practitioner and as researcher. Stake (1995) argues that all researchers take multiple roles. He states that "the intention of research is to inform, to sophisticate, to assist the increase of competence and maturity"

(p. 92). As a teacher-researcher my goal was not just to increase the competence and maturity of my students, but also of myself and possibly of other science teachers as well. Science can be empowering and emancipatory. The intention of this curriculum and of this study is to assist students and teachers in empowering and liberating their students. This intention also makes my role that of an advocate. Advocates want others to believe what they believe (Stake, 1995). In disseminating my study, my intent is to encourage other practitioners to engage in non-traditional instructional practices as well as in researching their own classrooms.



## CHAPTER IV

### RESULTS

#### **Overview of the Study**

The purpose of this study is to examine my experiences and my students' experiences with Sci-YAR. In doing so, I intended to empower myself and my students through research and to offer an emic perspective on teaching science and on implementing an innovative curriculum. By changing my approach to science teaching and learning, I was transformed and grew as both a teacher and as a researcher.

This study has a number of benefits. First I was able to take a systematic look at my teaching and in my role in the classroom. This ultimately helped and continues to help me to be a better teacher. Second, I interviewed my students to better understand their experiences in my classroom. Third, my students were not only positioned as experts in the classroom through their research projects but also as my participants. Instead of me giving them feedback in the form of grades, they were able to give me feedback through their interviews. I asked them to describe not only what it was like to be my student, but to evaluate me as well. Very rarely, if ever, are students asked to give thoughtful and candid feedback about their teachers especially my students who were only freshmen and sophomores at the time of this study.

This study began in January 2014 with the self-study. This consisted of weekly audio reflections and written journals as well as a content analysis of my daily agendas, lesson plans, and annual plans for the past five years. During the summer of 2014, after

my students had participated in the Sci-YAR curriculum, I began the phenomenological study portion of the research as I conducted interviews with my eight participants. The recruitment process of these participants took place in April and May of 2014 and was conducted by my Loyola University Chicago colleague, Elizabeth Coleman. As stated earlier, I was not present in the room when the consent and assent forms were distributed, and I was not notified of the students who agreed to be in my study until early-June of 2014, well after final grades were submitted. See Appendix C for the actual Data Collection Timeline. Interviews began shortly thereafter. Each participant was interviewed three times over a six week period with approximately three days to one week in between each interview. The interviews were audio recorded and took place at school, the participants' homes or at a public location of the participants' choosing.

### **Description of Participants**

My participants consisted of eight students – all boys whose ages ranged from 14 to 16. All participants were students in my biology course and conducted action research projects as part of the Sci-YAR curriculum. See Table 3 for more information regarding my participants.

### **Research Questions**

1. How has my teaching changed over the past four years?
2. How do I make meaning of my experience engaging in the Sci-YAR curriculum?
  - a. What am I learning about myself as a teacher and my students when they experience Sci-YAR instruction?

- b. What are my reactions while engaging my students in Sci-YAR?
- c. How does teaching Sci-YAR affect other areas of my life?
- 3. How do my students make meaning of their experiences while engaging in the Sci-YAR curriculum?
  - a. What are my students learning about themselves when they experience Sci-YAR instruction?
  - b. What are my students' reactions to Sci-YAR?
  - c. How does Sci-YAR affect other areas of my students' lives?
- 4. How does engaging in Sci-YAR impact me and my practice as I move forward in my career?

## **Results**

Interviews, content analysis, audio and written journals were used to address the above research questions. The interviews and audio reflections were transcribed and coded along with the written journals and content analysis using both pre-determined and emerging codes. The findings to each of the research questions follow.

### **Research Question 1**

How has my teaching changed over the past four years?

To investigate this question, I reviewed curriculum and reflected on my practice over the past four years beginning before the design and implementation of Sci-YAR up until this past school year ending in June of 2014. Most notably, my teaching changed in the following ways: (a) I was able to challenge power structures that exist in the

classroom and school writ large; (b) I changed my role in the classroom to more of a facilitator; and (c) I experienced a significant transformation in my practice.

**“I know that being a good science teacher means thinking differently and challenging the traditional approaches to education.”** This is an excerpt from my written journal dated January 24, 2014. I always viewed good science teaching as challenging the status quo – in particular the traditional methods of science teaching – in order to give my students a meaningful science learning experiences. Good science teaching occurs when teachers are culturally relevant, knowledgeable about their content and passionate about learning. Good teachers then use their skills and talents to form partnerships between students and their families and together create rigorous and meaningful experiences inside and outside of the classroom. Good science teaching is student centered and student led with the teacher acting as the facilitator and the student as the constructor of knowledge.

Through the design and implementation of Sci-YAR, I was able to see this more clearly and to gain the courage to be different as long as it served my students. An expert from a journal dated January 19 reads:

When I started teaching at [my first school], I was different. My first year I dared to arrange the desks in semi circles instead of rows. Eye brows were raised. I also had the students start off with an autobiography poem in a science class! So weird!

I really struggled with this feeling of being different for many years. When Sci-YAR was first implemented in 2011, I could no longer hide my differences. “I was scared but I also knew that there was a way to teach science that was different from the way these science teachers did AND from what I was currently doing” (written journal, January, 19,

2014). Making my teaching public through the innovation of Sci-YAR, I gained the courage and strengthened my conviction to be an advocate for my students and their science education.

My written journals and audio reflections are full of examples in which I promoted my students' research projects, and I talked openly about the differences in my teaching as compared to more traditional methods of science pedagogy. In the audio journal dated May 28<sup>th</sup>, which was also the day of the students' research symposium, I reflected on an interaction I had with two of the other science teachers who had not attended the past two year's symposiums:

I saw [the other science teacher] walk down the hall and say, "Have a great weekend!" And I am like, "Don't you want to go in [to the library where the symposium was held]? Don't you want to see what's going on?" So I kinda had to corner her and I had to ask [another science teacher] a number of times to show up, but they both showed up. I feel really good about that. I feel really good for myself that I was able to [get them to attend] even though I had to nag them, I nagged them to the point where they showed up and they did it for the kids.

Before Sci-YAR, I was doubtful that I would have been such an advocate of mine and my students' work. I wanted to fit in and to be accepted by other science teachers so badly, I would never have been so open with this curriculum that looks, sounds, and feels so different. Having seen how my students react to being given choices in the classroom and to being positioned as the experts, has helped and inspired me to exercise my choices in the classroom by putting on my teaching and for advocating for my students and their work with Sci-YAR.

**"We have established a partnership."** Another way in which my teaching has changed over the past four years is in the role I occupy in my classroom. I have

transitioned and continue to transition from the keeper of the knowledge and the one who has all of the answers to the one who helps the students uncover their own understandings. I facilitate the learning as opposed to control the learning. This change in my role has been possible by the relationship I have forged with my students; “We have established a partnership and that is why it is working and that is why I am feeling success and I am feeling happy and joy” (audio journal, April 18, 2014).

As facilitator, I need to make sure that my students get sufficient opportunities to be experts. This was achieved by giving students ample opportunities to present their research plans, data that they had collected, and of course their findings. The more I had them present the more they were able to take ownership. “I had [the students] present their research plans this year, which was different and they did a much better job. I can see that [their ideas are] coming from them” (audio journal, March 28, 2014).

As my role with my students’ changed, so did my role with the parents. In order to facilitate learning, I needed to not only form a partnership with my students but with their parents and families as well. Typically in the years prior to Sci-YAR, my communication included emails and phone calls to parents regarding a student’s obstacles or my concerns. During Sci-YAR, in order for the students to take control of their learning, they needed additional support in the classroom and their parents’ support at home. I made it a priority to reach out to the parents early and often to keep them updated on the goals of the action research, which stage the students were at in their research, and what support their child might need to complete his research. I found that changing my role with my students led me to reach out to my parents more often with

stories of how well their child was doing in my class. The success of this changing role was most evident at the research symposium. I reflected in an audio journal from May 28, “So [the students] were just proud of themselves and parents were coming up to me shaking my hand, saying that ‘This is great!’ So they really, they pulled it off.” When the parents witnessed the students positioned as experts, they got to see their child in a new light. This would not have been possible if the partnership between myself and the parents had not been forged over several months resulting in the parents understanding the process of their child’s research and how much ownership and control the students needed to take in order to be successful.

**“I am finally at this stage of my career where I am practicing what I preach.”**

The third way in which my teaching has changed in the past four years deals with my growing sense of confidence. I see this confidence reflected in the increasing sense of importance regarding Sci-YAR I create in the classroom, the surrendering of control, and the taking of risks.

At times, prior to Sci-YAR, my teaching was timid. I was nervous about challenging students too much for fear that would get overwhelmed and give up. This resulted in me slowing down the pace of the lessons or spending too much time on a concept to the point of boring my students. Sci-YAR helped me to see what was possible in my students and that they are capable of so much more than I ever realized:

[Before Sci-YAR] It took me forever to get through a concept. And I think because I was unsure that the students were getting it so I would come back to it and come back to it and spend three days on something. I would spend three days on topic selection. When really I wasn’t creating a sense of urgency. And I think I was nervous to do that because I wasn’t confident in my teaching (audio journal, February 22, 2014).

After having had experiences with Sci-YAR for three years, this fourth year I had a greater sense of what I was doing in the classroom, its importance, and how to adequately challenge my students. While I was able to give my students more control, I was also better about striking a balance between surrendering this control and still providing them with the structure they needed to succeed. This came out in my assessment and management practices; for example, I used the rubrics I created four years ago to assess the students' research plans and final projects. I referred to the detailed rubrics when giving the students feedback, and I stressed the value of aiming for excellent work. In addition, I was stricter on deadlines, which at times meant that the students had to complete significant portions of their research out of class. This made my class and their work a priority because I reinforced the importance and meaningful nature of their work.

This confidence also allowed me to give the students choices and more control.

In a written journal dated February 9, 2014, I write:

I love that I have come to a place in my career that I have the confidence to let up on some of the control and let the kids make some decisions. Five years ago, I couldn't do that. I was still drinking the *you-are-in-control kool-aid*. These kids are people. We can't control them.

This transfer of control often meant that my class was the loudest and most chaotic looking. Some students were graphing data, some were conducting experiments, and some were out in the hallway conducting an interview with one of their classmates. I needed to trust that I had prepared them enough that they would stay on task and remain focused. While there were definitely days when I swore the students would never finish



their research, at the end of the research symposium in late May, I could say with confidence that the students all remained focused and stayed on task.

With a loud classroom and perceived chaos also comes skepticism and whispers from my colleagues about the validity of my teaching methods. During the first few years of implementation, I wanted to explain Sci-YAR to everyone so that they would be excited and find it as interesting and transformative as I did. When that did not happen, I felt rejected by my fellow teachers and unsupported in my efforts. My students and the excitement they expressed when I told them that they would be choosing their own research topics, their methodology, their analysis tools and how they wanted their findings represented, helped me deal with the naysayers and critics. After this year's symposium, I had my colleagues and my administrators seeking me out to tell me how amazed they were at my students' work. I know that these risks are beginning to pay off and I will continue to take risks for my students. "Taking such a huge risk and having it pay off changed me. I for the first time became ok with the fact that I didn't quite belong. I had found a way to teach science and to make it meaningful to my students" (written journal, February 2, 2014).

## **Research Question 2**

How do I make meaning of my experiences engaging in the Sci-YAR curriculum?

In order to best answer this question, I needed to look at several different facets of my experiences with Sci-YAR. First, I investigated what I have learned about myself as a teacher and about my students. Second, I focused on my reactions to Sci-YAR during

its implementation. Last, I wanted to determine if and how Sci-YAR was impacting other areas of my life outside the classroom.

**Sub-question 2a: What am I learning about myself as a teacher and my students when they experience Sci-YAR instruction?** Through this self-study I was empowered to investigate myself as a practitioner. I needed to dig deep into the decisions I was making in the classroom and my interactions with my students. I thought I knew myself fairly well; however, I gained some valuable insights into my teaching. For instance, Sci-YAR has allowed me to redefine good science teaching, gain satisfaction out of taking risks, and deal with and overcome my doubts and fears. In addition, I gained some important understandings about my students as well.

*“I still doubt myself, but I know I am good – really good.”* This is a quote from my written journal from February 2, 2014. I spent the first decade of my teaching career wondering if I was any good. My evaluations were positive, but my administrators were not in the classroom with me every day as I tackled students who were unprepared, unable to stay in their seats, or completely disengaged. Nothing can shake my confidence like a disengaged teenager. Sci-YAR allowed me to tackle this disengagement and to feel successful as a practitioner:

I determine success to be a number of things. First is engagement. If I can get 14 and 15 year old boys to stay focused on a single project for more than 20 minutes or so, I view that as a victory. My students are movers. They are athletes. So they do not learn by sitting and listening (who does?). When I see them sitting in a group in a circle and they are all talking about their topic, laughing, joking and working together to create their concept map web [for their research topic], I know they are engaged (written journal, March 1, 2014).

Increasing student engagement was one crucial aspect to re-defining good science teaching. While the students were quiet when I assigned book work, they were not engaged. I wanted to see and hear more science talk, more ideas being shared, more plans being made. As I wrote in a journal dated May 26, 2014: “I want a room full of problem solvers, not fact regurgitators. I always felt this deep down, but my experiences associated with the Sci-YAR development and implementation have [freed] that part of me and let it run wild.”

I always knew my students liked me and enjoyed being in my class, I just felt as though there was more I could be giving my students. “Before Sci-YAR, I was a good teacher. I was a teacher who didn’t know what science teaching could look like. I was afraid to take risks” (written journal, January, 19, 2014). Sci-YAR gave me the tools and the courage to give my students more. I see the way in which they continue to challenge each other and me and I know I am a good teacher – a really good teacher even when one student gets squirrely and falls out of his seat or another holds up a sign in the middle of class that reads, “I Get Buckets.” As many teachers do, I tend to judge myself harshly on the day to day successes and failures that occur in the classroom. I often lose sight of the larger picture and forget that growth takes time and that my students need time to become comfortable and confident experts and researchers. When I focus on the failures (or perceived failures) I question my ability to serve my students as their teacher, but when I slow down and gain perspective on my students growth over the past few months, I am reminded of my passion for teaching. “I am called to be a teacher. I know deep down

that if I did anything else, I would not be as fulfilled. As stressful as my job can be I know that this is what I was meant to do” (written journal, January 24, 2014).

Sci-YAR not only afforded me the courage to take risks, but the satisfaction that accompanies these risks as well. I was so comfortable teaching the way I was taught. “I took the easy way out and cook booked it away. I also hated grading lab reports. Materials- check; Procedure – check; Data table – check. Barf. But I did it. To fit in” (written journal, January 19, 2014). The more I began to change my approach to science teaching, the more I was inspired to take risks:

I also get personal satisfaction out of the risk and of the unknown. This year especially I was convinced that the symposium was going to be a [total disaster] and my kids would not be prepared and totally disappoint me and everyone else. I was pretty sure that they would just wrestle for the entire two hours making me a huge embarrassment. Turns out again, I was right [in my original assessment of Sci-YAR]. When you give kids choices and make them experts, science learning can take place (written journal, May 26, 2014).

Teaching is always a risk. Attempting to get a room full of human beings to do what you say is never easy and nothing is guaranteed. That terrified feeling I still get when I begin Sci-YAR was a new group of students has become a much more welcome and comfortable feeling, because I know in five months I will be overcome with joy and pride for the work my students have accomplished.

Despite the satisfaction I feel in the classroom and my ability to take risks with relative ease, I still have to manage my doubts and fears:

I still struggle with the notion that kids learn in a quiet classroom, but I have come so far from the times in which I would beat myself up when things got too noisy. I think about this year in particular and there were times when my classes would get so loud and I was sure that no learning was taking place. Then fast forward to Friday’s research symposium and as it turns out – there was learning. I no longer derive satisfaction from a quiet classroom, now what makes me get out of bed in

the morning is the maturity and scientific thinking and reasoning I see at the symposium (written journal, May 26, 2014).

This self-study has allowed me to focus on these doubts. Science is meant to be messy, so it would make sense that science teaching would be messy as well. Before I was always apologetic for my classroom chaos, now it is a friendly reminder that students need a space in which they feel comfortable to be themselves in order to develop into the experts and researchers I know they can be. My students will at times get sidetracked and lose focus, but they would do that anyway. Now with Sci-YAR, getting them back on track can be done with ease because they are already invested in their projects.

It is difficult for me to see my strengths at times, but my weaknesses seem to be ever present. “I don’t always spend time reflecting on my successes. I get so focused and obsessive about my failures or perceived failures” (written journal, March 1, 2014).

These doubts can best be described by a written journal entry dated January 24, 2014:

I have this tiny voice that inside me that will sometimes whisper “But are they *really* learning? Isn’t this a glorified science fair? Is this work really authentic?” This voice is a giant buzz kill, but is always present. It prevents me from truly appreciating my hard work and from feeling like a great science teacher.

This voice is rooted in years of feeling like there was so much more I could do for my students. It is also rooted in the solitary nature of teaching. For the first ten years of my teaching career, I developed lesson plans, implemented curriculum, and assessed students basically by myself. I worked in a school in which I was the only person teaching my subject. Rarely if ever did other teachers and administrators engage me in conversations about my teaching or science teaching in general. I just assumed that I was doing an adequate job. It was not until Elizabeth Coleman and I began to design the Sci-YAR

curriculum did I teach in collaboration. Elizabeth became my co-teacher and through our relationship I was able to identify this doubting voice inside me and to investigate its origins.

Through this self-study, I have learned to manage this voice and my doubts by listening to my voice on the audio journals when I describe the success I just experienced in the classroom or by looking at what my students are doing well. These doubts also push me to keep inventing and re-inventing who I am and who I want to be in the classroom. I welcome these doubts more, not as that tiny voice critiquing my teaching, but as that tiny voice reminding me that there is still more growing to do.

***“I am learning that you really really cannot control people.”*** In a written journal dated April 26, I reflected on this notion of classroom control. I write: “As teachers, we are sold this idea that with *proper classroom management* you can get your students to sit, be still, and get excited about learning. Not true. You cannot get students to do anything they do not want to do.” Since Sci-YAR challenged me to change my role in the classroom from all knowing dictator to that of learning facilitator and my students’ partner in learning, I also needed to surrender the idea that I was in control of my students:

Sometimes kids just have things going on that are bigger than what happens in the classroom and sometimes no matter how thoughtful and meaningful your lessons are and how much time you spend trying to get them excited about your class, kids are gonna do what kids want to do (written journal, April 26, 2014).

Seeing my students as my partners and not wild animals that needed to be tamed allowed me to have more fun in the classroom and to enjoy my time with my students. I slowly

stopped worrying that my classroom was too loud or too chaotic and made science the focus not classroom management.

This new understanding then allowed me to encourage my students to take charge of their learning by offering up more control and decision making to them: “Now, seeing my students embrace Sci-YAR and making their own decisions regarding their research has made me love teaching science. My new favorite phrases are *what do you think; I don't know, you are the researchers; and sounds a like plan*” (written journal, May 26, 2014). The more power the students had and accepted, the more likely they were to stay focused and engaged in their own learning. Not only could I depend on them to direct their research but their behavior as well. I would never have gained this insight if I did not first take a leap of faith and a risk as I challenged my perceptions of classroom control.

Since accepting the notion that I cannot control my students, I have learned that students will surprise you. The students who I was sure were not going to take their Sci-YAR research projects seriously were the most dedicated. The students who I was positive would not be able to sit still long enough to write a detailed research plan did so in half the time allotted. The students who I was convinced hated me and my class were the ones with a passion for science that was and is unparalleled. In a written journal dated April 26, I discuss a student named Keith<sup>1</sup> and how he challenged me to think differently about my students:

Keith is another student who has surprised me. He was such a lump in the beginning of the school year or maybe it was I just wasn't engaging him correctly

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<sup>1</sup>All student names have been changed.

and he was bored. He has a passion for astronomy that I never knew. I question - how has it taken so long for me to become privy to this information?

Before the students began their research projects, Keith was turning in his assignments maybe half of the time and spent class time drawing in his notebook. Once we began Sci-YAR, Keith opened up to me gradually and by the end of the semester had one of the strongest projects in the class. “I had Keith on my mind all night. I am just so proud of him at the same time I am just so mad at myself for not realizing how awesome this kid is sooner” (audio journal, April 29, 2014). I have always prided myself on getting to know my students. These personal relationships allow me to help my students and to keep them motivated. I was shocked and a little disappointed in myself that I had a student in my class for five months who had this passion for science that I did not know about until we began Sci-YAR. At the same time, I am even more proud and confident in Sci-YAR and the foundation on which it is built that science needs to be meaningful and student-centered. Without Sci-YAR, Keith might never have gotten the opportunity to engage in authentic science learning experiences and become an outstanding researcher.

Sometimes, however, the students who are more successful in school – meaning that they get good grades, are respectful of their teachers, and cause a little distraction in class – struggle with the amount of freedom they are given:

Your students will surprise you. The ALS group in 7th period is comprised of (for the most part) students who are conscientious, responsible and minimal discipline issues. They are struggling to take this project and run with it. There is a lot of sitting around, hanging out, me having to remind them to get to work, etc. However, the wonder twins, Peter and Jerome, on the other hand seem to really understand what this project is all about – participating productively in science, directing their own learning, studying something they care about.



Peter and Jerome were regulars in the discipline office. They would often challenge the teacher and cause class disturbances. They chose to research how drugs impact a community. I suspected at first they did not think I would allow them to research this topic, but I did. When they saw I was serious and I trusted them, they began to trust me and themselves. Their maturity and dedication not only surprised me, but they were a huge success at the research symposium. Teachers who had issues with them in the class commented to me how impressed they were. Surrendering control allowed me to get to know my students and myself as a teacher as well as allowed my students to get to know me.

**Sub-question 2b: What are my reactions while engaging my students in Sci-YAR?** I have many varied reactions to my teaching and to my students' learning when we are engaging in Sci-YAR. My emotions ranged from ecstatic to terrified. On the terrified end of this spectrum, I struggled to communicate how unique this curriculum is to my students, their parents, and my colleagues. I also had trouble at times maintaining my motivation and that of my students. On the ecstatic end of the spectrum, however, I witnessed great successes in my classroom. I saw my students becoming empowered and in control of their learning. They sought each other out and learned from each other. They also were excited about being in my class. The students arrived to class early and encouraged me to hurry up and to take attendance because they wanted to get to work.

***“Most importantly, Sci-YAR has allowed me to love teaching science.”*** This is a quote from my written journal taken at the end of the semester. This quote reminds me that my positive reactions to Sci-YAR far outweigh the negative ones. One of the most

salient positive reactions I have had this past semester focused on my students taking control of their learning.

One instance of this transfer of control from me to my students is an increase in my use of the phrase “Don’t ask me, you are the researcher.” I state in a written journal entry dated March 1, 2014, “I love when I say this and then they without argument or frustration then go back to their tables and ask each other. This success lets me know that I am doing my job well. It makes me feel like I am a good science teacher.” Of course, this transfer of control does not always occur in an easy and seamless fashion. It takes time and patience, but the result is powerful. “Now, seeing my students embrace Sci-YAR and making their own decisions regarding their research has made me love teaching science” (written journal, May 22, 2014).

Another instance of my students accepting responsibility of their learning came in an unexpected place – rubrics. “I saw both Michael and Phil looking at the rubrics I gave them - the very detailed rubrics - and reading them and comparing them to what is on their board. That was amazing” (audio journal, May, 16, 2014). I distributed rubrics in order to assist students in preparing their final projects for the Research Symposium. Until this year, I never saw students using the rubrics with such independence and seriousness. Instead of asking me to look at their final projects and instructing them in what they needed to complete, they relied on themselves and had the confidence and trust in themselves to determine what their project needed.

In addition to assuming control for their learning, another positive reaction I had to Sci-YAR was seeing my students learn from each other. “Getting the students to learn

from each other is how I determine Sci-YAR success. I want them to see each other (and themselves) as experts. This happened when they started to rely on themselves and each other for advice, answers, and support” (written journal, March 1, 2014). My students tended to rely on me for the correct answers especially during the first semester before we began Sci-YAR. They are motivated to get good grades, not necessarily always to learn. To many of them, getting the correct answers means that they are learning. I know this is not always the case. I have seen so many bright students perform well on tests, quizzes, labs and projects only to struggle in their subsequent science courses. This indicated to me that while they are getting the *right* answers, they are not developing enduring understandings regarding science. Sci-YAR allowed me to challenge my students’ notions of *right* and *wrong* in terms of scientific thinking. Instead of the teacher having all of the answers, the answers lie with in everyone in the class community. I described what this looks like in my classroom from an audio journal dated February 14, 2014, “And it was one of those things where they didn’t need me. They stopped asking me questions. They were genuinely engaged.” I always believed that if students are positioned as experts in the classroom that they will take ownership of their learning.

When I see this occurring, I am overjoyed:

I’m ecstatic. Everyone is doing what they need to be doing. I have one group who has already moved on taking action. I’ve got interviews happening. I’ve got great questions being asked and answered. I’ve got kids reading on their own independently, solving their problems. I am filled with joy. You know, it’s working. I knew it was going to work. And I knew it was going to work with kids who have not had the greatest success with school before. Yes! I was right! Celebration! (audio journal, April 18, 2014).

This excerpt also illustrates my excitement when I take a risk and am successful.

Allowing students to learn from one another requires us as educators to trust and to believe that our students have knowledge that can contribute to the educational experiences of everyone. It means that every student is viewed and positioned as scientists, as researchers and as experts. It is difficult to see these students as experts especially on those days when they argue, joke, test boundaries, and eat Cheetos in your face despite telling them that food is in no way allowed in the lab; however, the rewards far outweigh the risks.

Getting my students to be excited about anything can be a struggle. Sci-YAR, however, has the capacity to make my students enthusiastic about attending my class and about doing science.

I think about like today when on a Friday, on a Valentine's Day holiday, on a dress down day, I can look around the room and see my students walking from sign topic to sign topic deciding what they want to research. No one wrestled today. No one teased each other today. The class was eerily quiet. I can see, hear, and sense that they are beginning to buy in (written journal, February 14, 2014).

Seeing my students running into my class and jumping right in to their research projects supports the argument that Sci-YAR provides meaningful and engaging learning opportunities. This excitement I see in my students is one of my favorite things about Sci-YAR. Since students are given choices in my class, from their topic to how they want to present their results, students are validated for who they are. When they make decisions, they are encouraged and challenged and supported. They are taken seriously. This changes everything about the teaching and learning dynamic that occurs:

I also love the way the climate of the classroom changes when we start with the Sci-YAR curriculum. You can see and feel the change. One day they are punching each other and then next day they are punching each other in the hallway *before* my class. They go from me policing them to them policing each other. The static and the noise in the class is gone (or at least reduced). They are excited to be in my class. They are excited to learn (written journal, February 9, 2014).

One of my challenges was in accepting my students for who they are. I always assumed that if students were quiet that they were learning. I know now through my experience with Sci-YAR that this is not the case. My classes of 25 plus boys are not going to be silent. But by accepting them for who they are and by validating their decisions with their research, I am able to allow them to be goofy and silly and intelligent and important. My students are then comfortable in my classroom and look forward to being a part of this community and in turn they grow excited about learning and doing science.

Another positive reaction I had to Sci-YAR was one I was not expecting. I realized that I was gaining confidence in my teaching and in my work as a researcher. For instance, “Sci-YAR gave me confidence in my teaching and made me feel like I belong at Loyola. I have always felt different as a teacher and that I never fit in the science teacher best friends club” (written journal, February 2, 2014). In my experience, science teachers prided themselves on having a reputation for being strict and for not giving out A grades. They came from the belief that correct answers in science did exist and whether or not a student could regurgitate the correct answer determined how successful that student was in their class. I knew I did not hold those same beliefs; thus, I felt as though my classes were not as rigorous. These insecurities intensified when I began my doctoral program at Loyola University Chicago. Not only did I feel different

from science teachers but from science education researchers as well. I assumed that science education researchers held that same definition of rigor as my science teacher colleagues did (which many of them still do).

Witnessing my students' success and joy in the classroom when I teach the way I have always wanted to, strengthened my confidence and my beliefs that science teaching and learning can be chaotic, loud, and student centered. During my first several years of teaching, I was nervous about letting my colleagues into my classroom for fear of judgment and criticism. Now I welcome it. "I am so excited to show off my kids and their awesome work at the research symposium not only to their parents but to my colleagues as well" (written journal, April 18, 2014). Opening up my classroom doors and feeling free of snide remarks, nasty comments, and negative feedback, is one of the most positive impacts Sci-YAR has had on my teaching.

***"I'm terrified that my students are not going to complete their projects on time. I'm terrified that this curriculum is not as transformative as I believe."*** This is an excerpt from a written journal entry dated April 18, 2014. One moment I can be overwhelmed with feelings of success and quickly I can become consumed with doubt. This doubt is rooted in the struggles of implementing Sci-YAR. Throughout this past semester, I have encountered obstacles in communicating my expectations to my students and my colleagues; helping my students deal with the amount of freedom that comes with Sci-YAR; and keeping me and my students motivated.

I have struggled with communicating the theory, structure and expectations of Sci-YAR to my students, their parents and my colleagues. This struggle has caused me at

times to have negative reactions to Sci-YAR. For instance, I have not yet found an effective way in which to help my students to trust me and the Sci-YAR process and to see the big picture. I wrote in a journal dated April 2, 2014:

One obstacle has been communicating to the students at the start of the project how much responsibility they are going to have to take. They are so used to being bossed around and spoon fed. When I tell them that they are going to make the decisions in what, how and where they study, they don't quite believe me.

Because Sci-YAR is such a different approach to teaching and learning, my students, who are mainly fourteen and fifteen years of age, often do not realize initially that they are going to be the primary decision maker in their education. These students got nervous and then many times acted out with disruptive behavior. “I have a lot of gigglers in my classes. Kids who when you talk to them one on one or in their groups – giggle. What is that about? Immaturity maybe? Discomfort with taking on this responsibility? (written journal, March 22, 2014).

When I have a group of students who are giggling or engaging in other disruptive behavior, I at times reacted by getting upset and even angry. I am so passionate about Sci-YAR and I get frustrated when my students do not see the potential and excitement this brings to their learning. “I have anger bubbling from within – like I’m going to explode in your face – anger. I’m mad at them for not working with me. I’m mad at them for not seeing this opportunity that they have before them” (audio journal, April 18, 2014).

Sometimes the students expressed their discomfort by acting out in loud and disruptive ways and sometimes they do so by shutting down. “In class there seems to be this complete lack of urgency. Kids are just not engaged. I ask questions and I will get

literally them staring back at me with blank stares. There just doesn't seem to be communication" (audio journal, May 16, 2014). Sci-YAR begins in January and continues until the end of the school year in late May. While I attempted to explain the entire process in January, my students needed to get into their research in order to fully understand the expectations of Sci-YAR. Sci-YAR requires that students stay focused and engaged while working on one project for five months. Distractions are understandable; however, I assumed that the lack of urgency exhibited by my students is a negative reflection of my ability as their teacher:

I am mad at myself that I cannot communicate what I need from them. I know you can't reach all kids. I get it. There is going to be some kids that don't want to play ball. I totally understand that, but at the same time, it's frustrating because, I believe if anything can reach all kids it's this curriculum. I am frustrated and confused and I don't understand (audio journal, April 18, 2014).

These are the days in which I doubted myself. As stated earlier, Sci-YAR requires me and my students to become partners. I relied on them just as they relied on me. While this partnership ultimately resulted in my students conducting authentic research and accomplishing great things, it can also expose my vulnerabilities and insecurities. Becoming my students' partner required them to learn from me and for me to learn from them. Many times, my students know more about their topics than I do. I am challenged to put my ego aside and let them teach me. It also required my students to see me as a person – not just another robot teacher who does not have feelings or interests outside of the classroom. When I get frustrated, I need to tell them that I am frustrated and why. I had be vulnerable in their presence which can be uncomfortable. Just as I needed to



tackle my doubts, in order to be successful in the Sci-YAR classroom, I needed to let my students help me tackle my doubts despite how unusual and uncomfortable it might be.

Maintaining motivation for me and my students is another struggle that exemplifies this partnership formed between me and my students. We needed to depend on each other to resist fatigue. I realized that my students' motivation can be sustained if they pick a topic in which they are passionate. The topic selection process is the first step of the research process. "It just goes to show that if the student is engaged and they pick the right topic. This is the battle. Once they have the topic that interested in. It will all kinda go from there" (audio journal, March 21, 2014). Unfortunately the students who do not quite understand Sci-YAR might not select the right topic. They might choose a topic with which they have a mild interest just to get a good grade as opposed to selecting a topic that is meaningful to them outside of the science classroom.

While my students' motivation can be managed early on in the research process, my motivation does not seem to have such an identifiable fix. My motivation waned throughout the five-month implementation of Sci-YAR especially when I became overwhelmed. "Teaching is tough work especially when you have seventeen groups all doing different things while researching different topics. It makes my head spin keeping track of it all" (written journal, April 18, 2014). Again, I relied on the partnership forged between my students and me. This stress and overwhelmed feeling was rooted in my doubts and fears that my students will not focus if I am not standing over them nagging them to work. I needed to trust in our relationship and partnership that both my students

and I are willing and excited to work together to foster a climate of respect to achieve a common goal.

My motivation can also be challenged by the temptation to do only the minimum like many of my colleagues. I explored this issue in a written journal from January 24, 2014:

Sci-YAR, while totally genius (ok, I may be biased), is also stress inducing and exhausting. Seventeen groups of kids spanning over two periods all researching different topics at varying stages in the research process. I wish I could be like the many tenured teachers who just turn it off and repeat the same lessons year after year just hoping that they reach every student. Why must I create more work for myself?

The ultimate motivators are the times in which my students exceeded my expectations.

Despite my doubts and being completely overwhelmed, at the end of the semester I stood back and realized how much my students and I have grown.

In addition to struggling with communication, discomfort, and motivation, I have also encountered obstacles with Sci-YAR's acceptance among my colleagues. "This curriculum is not getting the recognition it deserves at least at school. My kids are doing amazing work. They are becoming thinkers and doers. And still everyone still looks at this curriculum as *oh that research thing you do*" (written journal, March 22, 2014).

Despite sending email updates regarding my students' work; asking my colleagues to be participants in my students' research; and inviting the entire school community the final Research Symposium, interest in Sci-YAR was minimal among my fellow teachers. A few teachers do understand the meaningful and rigorous nature of Sci-YAR. These are the colleagues that encouraged me and supported me year after year. Unfortunately, these people are few and far between. "My colleagues really have no idea how hard I am

working for these students and how much I care. And if they do, they don't really show it" (written journal, March 22, 2014).

**Sub-question 2c: How does teaching Sci-YAR affect other areas of my life?**

Sci-YAR has dramatically impacted my life and my relationships with my friends, family and colleagues. Professionally, Sci-YAR has given me the tools to create and to maintain meaningful connections with my fellow teachers. Personally, through the design and implementation of Sci-YAR I was challenged to make my teaching public. My teaching is such a personal endeavor, making it public is akin to me exposing my vulnerabilities. This vulnerability as extended outside of the classroom and in turn has strengthened my personal relationships as well.

*“One way I know for sure Sci-YAR has changed me is in the way I see myself as a leader.”* This quote was taken from a journal written on May 11, 2014. When I first arrived at my current school four years ago, I experienced a significant culture shock. I came from a new school staffed with teachers passionate for teaching who welcomed collaboration. We worked as a team. My current school is a well-established school with a rich history and a solid reputation. Some teachers have this passion for teaching I encountered at my last school, but many do not. I was not welcomed by everyone. When I would make comments and suggestions during meetings, I was given eye rolls and snickers. I felt like an outsider. Sci-YAR has enabled me to change my position at my school among my co-workers by changing how I viewed myself.

I describe the first time I implemented Sci-YAR at my current school and the struggle I experienced in an audio journal from May 8, 2014:

When I came to [my current school]. I didn't get any opposition. There were really no questions. It was like, "Sure, go ahead." But in terms of support from my fellow science teachers, there is none. The first year was really was kinda tough. I felt sad and alone, because no one came to the symposium. No one asked questions. No one seemed to show any interest.

Because I faced some obstacles getting acclimated to the new school culture and to my new colleagues, I did not feel as though I can reach out to the school community to ask them to be an integral part in the Sci-YAR process and in the students' research projects. The first year I implemented Sci-YAR at my current school, I isolated myself from my colleagues for fear of criticism and judgment.

Eventually, I became more comfortable with my new surroundings and I was inspired by my students' amazing work. During the past few school years, I made more of an effort to personally invite people to be a part of my students' research. I first found a group of allies in the athletic department. "The coaching staff and the trainers have been great in terms of giving my kids interviews and things like that, but from the science teachers it's just not there" (audio journal, May 8, 2014). I knew that I needed to create stronger relationships with my colleagues in order to better facilitate my students' research. At the beginning of this past cycle of Sci-YAR, I sent out an email to the faculty explaining Sci-YAR and informing my co-workers that they may be asked by the students to assist them in their research. I then invited the faculty to stop by my room anytime to observe the students working on their projects. This required confidence and humility on my part to open myself up to my colleagues many of whom did not greet me with open arms when I first arrived on campus four years ago.

“I was not accustomed to taking such public risk in my teaching. I knew I was good at forming connections to my students, but I guess I just thought that students and teachers just thought I was too easy – a push over” (written journal, February 2, 2014). Because I allowed my students to have so much choice in my class, my fellow teachers would often question me, my teaching methods, and my classroom management. I became closed off and defensive. This mind set did not serve my students and did not make me feel as though I belonged. I allowed myself to become vulnerable for my students. I wanted them to get recognized and celebrated. They made me love teaching science again and I wanted to show them how important their research was.

I still have work to be done with regards to my relationships with the other science teachers. We have different views of good science teaching and learning; however, we can still work together to give our students positive science learning experiences. For the past few years, no one from the science department attended the Research Symposium. This past year, I invited each teacher personally. I knew it was important for the students to have as many teachers attend as possible. I was nervous about being viewed as different, as a trouble-maker, and as obnoxious. I wanted to fit in. Now I see myself as an advocate for my students, so if I need to go outside my comfort zone to forge relationships or to ask for support, I will. I will do it for my students.

***“Sci-YAR has also re-ignited my passion for teaching which has made me a nicer person outside of the classroom.”*** This is an excerpt from a journal entry written on May 4, 2014. I cannot separate the teacher in me from the person in me. Sci-YAR reminded me why I love teaching science. Since I am inspired at work, I have become a

stronger, more focused individual making me a better friend, wife, sister and daughter. “Personally my new mantra is – other people’s opinions of me are none of my business. Sci-YAR has made me feel like my work is meaningful” (written journal, February 2, 2014). Engaging in meaningful work has allowed me to handle the complexities of life with patience. My work is such an enormous part of who I am. When I feel confident in my work, I am able to feel more confident in life. “I know that my students are happy and engaged in my classroom. I am less likely to bring a bad day home because I know bad days don't last forever. Sci-YAR has made me focused, happy and filled with purpose” (written journal, May 4, 2014).

One area in which Sci-YAR has changed me personally is in my collaboration and friendship with Elizabeth Coleman. We created this curriculum together and have implemented it together. She has been an integral part of the day-to-day classroom activities. She has seen me teaching on my best and worst days. Elizabeth has been by my side feeling my frustrations with my students and my colleagues and sharing in my successes. “Because Beth and I have this shared experience of Sci-YAR, I have found a friend for life” (written journal, May 4, 2014). She has become my support not only in the classroom but out of it as well.

Beth will be in my life forever. She has been my biggest, loudest cheerleader over these past 4 years. She has seen me in the classroom more than anyone else. Basically she has seen me vulnerable and ugly crying and she still thinks I am great. This bond we have would not be possible if it was not for our professional and personal collaboration (written journal, May 4, 2014).

My relationship with Elizabeth has taught me that being vulnerable and sharing yourself and your passions strengthen relationships. I do not need to be perfect in order to have

perfect relationships. Beth validated me for who I am despite being exposed to my imperfections. Our friendship has encouraged me to be vulnerable in front of my other friends and family. Doing so, while scary at first, has allowed me to feel love and support in a way that I had not prior to our friendship. Beth has given me confidence in the classroom and in life.

### **Research Question 3**

How do my students make meaning of their experiences while in engaging in the Sci-YAR curriculum?

In order to investigate this research question, I needed to interview my students. Each participant was interviewed using the same format as designed by Seidman (2006). Each participant was interviewed three separate times. Interviews were structured as follows:

- Interview One: Focused Life History
- Interview Two: The Details of Experience
- Interview Three: Reflection on the Meaning

The goal of these interviews was for participants to describe their experiences in my classroom while engaging in Sci-YAR in order to make sense of them. As stated earlier, my participant group was comprised of eight students with ages ranging from 14 to 16 years old. Table 3 lists the students who participated in the study.

**Research Question 3a: What are my students learning about themselves while engaging in Sci-YAR instruction?** My participants expressed learning about themselves academically, as experts, and as leaders. Some students were surprised to

uncover that they are leaders; some realized that they could teach their teachers and families; a few identified as being unique students; others concluded that learning can occur while having fun; and some felt as though they were growing as scientists.

***“I never knew I was a leader.”*** This was a quote taken from Andrew’s third interview. I had just told Andrew that his group identified him as a leader. He reacted with surprise.

Me: People in your group saw you as a leader.

Andrew: Really?

Me: Yes. They definitely do.

Andrew: Oh my god.

Me: They called you the connector.

Andrew: Wow, yea?

Me: Is that surprising to you?

Andrew: Yes, it is.

Me: Why?

Andrew: I was never a captain in hockey or anything. Captain’s supposed to be a leader but I never thought I was a leader.

Andrew went on to explain that he tends to “goof off” in class and that in his opinion, leaders and experts do not goof off, and thus he never saw himself as a leader before. Leaders, according to Andrew, are serious all the time. Since he gets distracted in school and is not a team captain, he could not possibly be viewed as a leader. Sci-YAR started to help Andrew to see himself as a leader. Andrew’s research topic was on hockey injuries



and since he was the only hockey player in his group, he needed to take the lead in designing their research.

Andrew was not alone in his struggle to see himself as an integral member of his research group. While Andrew's group viewed him as a leader, Andrew struggled to do so. Keith and Bob had similar experiences but in their cases they had difficulty identifying as experts. Bob argued that he is not an expert because he does not know everything the way in which scientists know everything. For instance, Bob admitted that he does not know anything about string theory. If he were an expert, he would understand string theory. While Keith did admit that he does know quite a bit about astronomy, he did not feel as though he was an expert. Keith stated, "I feel like I don't know enough to officially say [that I am an expert]." My students describe experts as people who know everything, who are perfectly behaved, and who never make mistakes.

A few of my students did identify as experts, but not in science or in their research topics. They saw themselves as experts in social or emotional domains. For instance, Phil stated, "I wouldn't say I'm an expert [at anything], but I'd say I'm pretty good at certain things. I'm pretty good at leading people. I'm really good at showing people the way, helping people stay off the bad path." David agreed with Phil: "I'm good with helping people. If they have a problem going on at home, I can talk to them about it." My students still viewed science as an external body of knowledge and in order to be proficient in science they felt that they must first must memorize every piece of information within the body of knowledge. However, when it came to helping or

being a good friend, they could easily identify as being good at those things. Being a good friend does not require memorization, tests, or lab reports.

Sci-YAR challenged my students to define and redefine their position in the classroom both as leaders and as experts. They tended to see themselves in terms of what they could not do as opposed to what they could do – what they felt successful at. While they struggled to label themselves as leaders and experts, they were able to discuss how they acted as leaders and as experts through their participation in Sci-YAR especially during the Research Symposium.

***“The people that I was presenting data to, they were actually learning something -- not by an adult who did the experiment [but by someone who was] younger and knew the outcome of it.”*** This quote is from my last interview with Peter as he recalled his excitement in participating in the culminating Research Symposium. Peter expressed similar views as my other participants in his struggle to label himself as an expert in the science classroom. Despite this struggle, my students felt pride in their research, and felt as if they changed the way people viewed them because they were able to answer rigorous questions. While my students did not perceive themselves as experts, they did act as experts while engaging in Sci-YAR.

First, my students acted as experts in that they were able to present their data to their teachers, parents and fellow students and, in doing so, changed the way they felt in their interactions with others. Phil recalled this moment from the Research Symposium: “I remember talking to my dad and a lot of other parents about what we learned. It was crazy how much data we collected and how much that I learned about spiders.” Phil did

not realize that he had so much knowledge about his topic until he was able to present and answer questions about his research. Peter also had a similar realization:

For all the work I put in, I really like to show it off. I love to be like, this is what we learned. I like to share information with people. I like to make people smarter. I like to make them learn new things. I like to make them more interested in certain subjects.

One of the critical aspects to Sci-YAR is that it engages students in collaboration and challenges them to make their research public. When Peter showed off his work, he achieved both. First the research was done in collaboration, but also he collaborated with those in attendance at the Research Symposium. In addition, every student participated in the Research Symposium as well as other opportunities on a smaller scale to present their research. These opportunities to make their work public allowed students to feel important, like Peter did, and feel as though they could make people smarter. When positioned as people who have knowledge that others do not, my students acted as experts. They became the teachers, the knowers, the experts and they gladly accepted these new roles.

Sci-YAR also changed the way they felt around certain members of the school community. For instance, Jerome, who had struggled with his relationships with many of his teachers, was able to position himself in a different way through his research:

Jerome: We also got some good feedback from the parents, even some of the teachers, even teachers I had problems with.

Me: Yes! Talk to me about that.

Jerome: It was weird. I had such hard time in their class but when they seen me doing it in your class, they were feeling me.

Me: How did you feel during that time?

Jerome: I felt great!

Me: Why?

Jerome: I was showing them; maybe it's you, because I can get some work done.

Jerome described not only how Sci-YAR can help students to learn about themselves, but how they can learn about their relationships with others and how they fit into the power dynamics of the school. As stated earlier, Jerome was a frequent visitor of the Dean's Office. He got in trouble often for challenging teachers, questioning authority, and appearing defiant. Jerome used his research to assert his knowledge and skills to gain new realizations about his position at school.

Jerome, Phil, and Peter all had new experiences either as experts or as someone to whom people listened. This brought them feelings of pride, excitement and surprise. Being an expert is more than just knowing things: it is also about being able to communicate your knowledge. Sci-YAR gives students the space to communicate their knowledge and for it not to be suppressed. My students were able to know things and communicate their knowledge in a way that made them feel important in the presence of those who attended the Research Symposium.

In addition to presenting their knowledge, my students also acted as experts as they answered difficult questions regarding their research. One incident involving another science teacher was highlighted separately by two of my participants. This particular teacher has a reputation for being intimidating. Andrew recalled a moment when this teacher asked his group how another athlete (not included in their study) died while playing football. Andrew stated:

The question was, 'How did this person die?' Then I just quickly said, 'Brain trauma, internal bleeding in the brain.' I just came up with it really quick and it's like, 'Oh, okay, yes.' Then she just went on with it [and accepted the answer]. [My group members] just turned around and they're like, 'Wow, you saved us from getting a bad report.' I was terrified. I didn't even know what I said, I just came up with it myself. It was the weirdest thing.

Andrew described his experience of answering a tough question regarding his research on hockey injuries to this same teacher. By answering this question and coming to the rescue of his group, Andrew acted as a leader and as an expert despite not being a team captain and having a tendency to “goof off” during class. Andrew was gaining the confidence to assume a new role in his group. He became an expert in leading his group members in their scientific inquiry.

Bob was in Andrew's group and recounted the same story in our second interview. He admitted that he was intimidated by this teacher and struggled to answer her question. Bob expressed relief, pride and surprise when Andrew came out of nowhere to answer the question and to impress this tough teacher. While Phil was in a different group, he also was questioned by this science teacher:

Phil: [The other science teacher's questions] were the hardest questions I've ever been asked in my life.

Me: Talk to me about that.

Phil: She really got into detail. Honestly, I was right back at her with an answer. Being questioned and then answering those questions is what experts do. My students admitted that at times they were nervous but they often surprised themselves and others by knowing the answers. They learned what they were capable of through their participation in Sci-YAR.

Keith, on the other hand, had more confidence going into the Research Symposium. “To [have] people come up and say, ‘Okay, show me your presentation’ and ask me questions about it, it was like a dream come true because I never get that.” Keith was the student who struggled the first semester. He was not engaged in my class. He often spent class time sketching in his science notebook. Once we began Sci-YAR second semester, Keith was a totally different kind of student. From the beginning, Keith was confident in his knowledge of astronomy and presented his research with ease. “I mean yeah there are some good questions but I still knew the answer. Just to enlighten them it was really like really fun.” Keith’s transformation came about because he got to study something he was interested in and share his expertise with others. Sci-YAR allowed students like Keith to demonstrate their expertise, which got them more engaged in learning. Whether my students called themselves experts or not, they acted and felt like experts. Positioning students as experts in the classroom is achieved when science teaching and learning becomes meaningful for the teacher and students. This positioning comes as we engage in Sci-YAR together.

***“I would say I’m not your average student.”*** This quote was taken from my first interview with Peter. He continued, “The average student just comes in and does their work and leaves. I try to do something different than the average student. What an average student wouldn’t do.” Peter explained that he gets bored in class and while “the average” student would just sit silently, he attempts to break the monotony by asking off-topic questions to see how his teachers would react. This pattern of behavior often resulted in Peter being sent to the Dean’s Office. Peter’s comments are similar to many

of my participants in that they not only struggled to identify as experts, but as good students as well.

Many of my participants admitted they were not engaged in their other classes. Keith stated, “I feel like there is more important things to worry about than me learning, what’s the circumference of so and so.” Keith did not connect with the content and instruction in his other classes. Keith did not consider school as the primary vehicle for learning and thus did not consider himself a student in the traditional sense: “I kind of identify myself as a student of Albert Einstein, Isaac Newton, Neil deGrasse, I kind of like when I research all their stuff it kind of makes me feel like I was there.” Keith needs to connect to the topics being taught in class and to feel like he “was there.” When Keith does not connect to the material, he cannot identify as a good high school student. Keith can, however, identify with being a student of scientists of whom he has researched on his own. Sci-YAR allowed Keith to bring his interests outside of the school into the classroom. Keith used the knowledge acquired by studying these scientists to achieve success in my class.

Andrew shared some of Keith’s same opinions, “I really don’t like school. The only thing I like about school is meeting the friends there and I mean the teachers that are nice.” However, Andrew saw school as stressful. “I usually don’t do good on exams. I study, but it’s just, that’s not me. Homework every single day, and if you miss an assignment it drops your grade. Keeping your grades up is so hard.” Bob also identified as struggling on tests. He described himself “as a student, I think I’m quiet, maybe. I don’t talk to people. I’m not that social. I just want to get the notes, do the work and try

to get a good grade because I'm not a good test taker at all." It should be noted that Keith, Andrew and Bob all completed exceptional research projects and I would describe all of my participants as good students.

Bob and Andrew also achieved honor roll status and were successful in their other classes. When I asked Andrew if he would describe himself as smart, he replied in the following manner:

Me: Do you think you're smart?

Andrew: No.

Me: Why don't you think you're smart?

Andrew: Because I don't get the 4.0 GPA.

Me: That's the only indication of being smart?

Andrew: Yes.

For my students being perfect is a sign of intelligence. Bob does not consider himself smart because other students have higher grade point averages. "They know that stuff doesn't come easy to me so I have to work at it and study." At first, my participants did not view themselves as good students or as experts. Through their engagement in Sci-YAR, they were able to see school and their participation in school differently. My participants began to see themselves as more capable and productive members of their class and school communities.

***"You actually learn when you're having fun."*** This was Michael's response when I asked him about conducting his research. He admitted that he was able to learn because engaging in Sci-YAR was fun. According to my participants, Sci-YAR gave



them an opportunity to think differently about school. My participants willingly identified as being scientists or good science students, despite their hesitation about being good students. David explained, “I can’t sit down and just read something and know it. Your class is a good example because we were always doing something, either with groups or a poster board or something like that.” My participants often stated that they struggle in classes with a more traditional approach to teaching similar to that of Freire’s banking model. Here David argued that he needs more engaging learning experiences in order to develop deep understandings about a topic. Many times these meaningful learning experiences can make learning both fun and rigorous. Andrew agreed that learning can be fun and further describes this connection between science learning and fun:

Like in Theology, we always had to just sit down and read. Half the time, I just fell asleep. I didn't learn anything from that. I like interactive. Your class is a perfect class for me because it was so interactive. Everyone was so into it. It was just fun. It was just a fun class and I had fun in it.

Admittedly, just because a student is having fun in a science classroom does not automatically mean that he is forming enduring understandings about the natural and physical worlds. Fun, however, does indicate that a student is interested. Since many of my students stated that they would often get bored in other classes (including their previous science classes), Sci-YAR was able to engage students in science and in different and exciting ways. My participants learned that they could still learn while having fun.

Both Phil and Michael admitted that they needed to learn by doing. Peter agreed and stated that because he was able to learn by doing, he enjoyed participating in my class and in Sci-YAR so much more:

I can't just have someone all the time tell me what to do. Like the little lab kits have instructions and they'll give it to you and basically you're supposed to figure out what the question is on the little worksheet and answer it. It felt different that I was the actual scientist and I was coming up with my own questions, like making up my own worksheet, and coming up with my own answers. I felt like an actual scientist.

Sci-YAR positions students as experts, as scientists. In doing so, students are engaging in rigorous science instruction, but because they are in control of what and how they learn, class and school and learning become fun. My participants learned that they could be scientific thinkers despite not getting straight As, being a team captain, or spending too much time in the Dean's Office.

***“Scientists usually do science by getting down and dirty and getting into it. You can't sit there and watch it happen. You have to make it happen.”*** This quote is from Phil's second interview in which he explained that science is not just “going for a checkup at a doctor's office.” Sci-YAR gave my participants a more authentic picture of what scientists really do in their work and it allowed them to “get in on the action” of science, rather than just “sitting there and watching it happen.” In addition to feeling like scientists, my students also acted like scientists throughout the Sci-YAR process, particularly as they collaborated to make claims and support their claims with evidence.

Bob explained why it is important for them as researchers to back up their research with evidence: “Well, because if you don't you have no credibility. Like what you're stating. You have to have good proof and good resources so it can actually be

believable.” Bob continued as he explained how his process of researching hockey injuries is the same process that scientists use:

I think what we did would be exactly what scientists do. I mean, you have a theory, you have a theory that you have to prove and do research on. You have to actually research the topic and get sources, get information. I’m pretty sure that’s what scientists do with their theories. Probably get first-hand information and maybe information from more of an expert on the topic like we did with [the hockey coach] and the varsity players because they play the sport so I’m pretty sure they’re experts on the sport. And come out with a complete, smart, educated answer on the solution.

For Bob, gathering information, formulating claims or “theories” and then supporting those claims is both what his group and what scientists do. Peter also sought to support his claims with evidence and did so because he was critical of information he had gathered about his research on how drugs impact a community:

Peter: The information was accurate. It was just statistics and facts. I just wanted some people's actual opinions.

Me: Why was that important to you?

Peter: Anybody can make a website and make it seem like drugs are the best, or drugs are the worst with statistics. But if I get a sense or feeling of someone who has actually experienced the stuff – and not just going off statistics, going off their experience – I think that would be better.

Both Bob and Peter evaluated their data and challenged themselves to dig deeper into their research to ensure that they had supported their conclusions just like scientists and researchers do every day. My participants explained that presenting their data did make them feel like scientists, but so did the daily tasks associated with Sci-YAR. My students questioned their own data and that of their classmates not necessarily because they would be issued a grade, but because they wanted to know the answers to their research questions for themselves.

Michael, Andrew and Jerome also discussed how they were able to think and act scientifically in different ways. For instance, Michael explained that they were scientists in the manner in which his group collaborated. He stated, “We all had to compare and we all had a job to do in this project and then we combined everything.” For Andrew, his group began the research process by first deciding on a plan to collect and organize their data. He explained that this is also what scientists do. “Scientists, they think about what they're going to do. Sort of like a pregame.” Jerome also came to some conclusions regarding scientific inquiry through his Sci-YAR research:

Jerome: In science, there's no right answer. You don't have a ... there's not a specific answer that you're looking for.

Me: Did you always think that?

Jerome: No. I used to think that there was always something that you had to find.

Me: What changed your mind?

Jerome: This year when you told me that it's not always a right answer.

Me: Did you believe me, though? Why did you believe me? I could just be lying to you.

Jerome: Because when we...when we were doing experiments and stuff everybody had different answers, but it came to be the correct answer.

For Michael, Andrew and Jerome, scientific thinking and doing was about supporting your conclusions as well as working together, planning, and accepting that people can interpret data differently. Sci-YAR allowed my students to uncover how scientists really do science. They not only felt like scientists, but did the work of scientists as well.

A few students even explored the conflicts between science and religion that has been plaguing scientists for centuries. Phil explains the inherent difference between the

study of science and the study of theology. “We know most things about theology, and science is never ending. There's so many things about science that carry on for eternity that you can just keep learning.” Keith’s conflict is more complex. Keith’s research was centered on astronomy in particular the formation of the solar system:

Then this guy is talking about like this is why we shouldn't have science in our schools because it's really like affecting our religious views. I really feel like there's all this other proof of like how much older the earth [than] 6,000 years. I mean it's ridiculous and I remember I'm thinking to myself so why is there this giant fossil record from the dates back billions of years ago and you're saying God created all this in seven days.

Keith continued to explain that science has proven religious beliefs wrong throughout history like the Earth revolving around the sun. Keith felt that “God just like a dwindling theory itself. It’s what I believe, I mean if you’re just going off [religious doctrine] sooner or later we will know and it’s only a matter of time”. Keith argued that science will prove religion obsolete in the near future. As expected, Keith received some resistance from his friends and family especially since his is attending a Catholic high school. He has learned to rely on his research and his ability to support his opinion with evidence in order to engage people in conversation. As Keith states, “I am a man of science.” Sci-YAR provided the vehicle for Keith to safely explore this conflict. Since Keith and his group were directing their research, he was able to discuss and research his struggles with science and religion without fear of being told he was incorrect. Sci-YAR is predicated on the value of students’ localized prior knowledge, Keith was able to use his prior knowledge to expand his thinking.

**Research Question 3b: What are my students’ reactions to Sci-YAR? In**

addition to learning about themselves as experts, teachers, thinkers and scientists, my

students experienced other positive reactions to Sci-YAR. Most notably was the freedom they encountered while directing their own learning through their research projects. They also enjoyed the reflection component of the curriculum, which is one of the key tenets and unique features of Sci-YAR. My students also had some concerns and less than positive reactions to the curriculum as well. Many had difficulty working with the other members of their research groups. They also struggled to balance their research with the other demands of the course and in doing so desired more structure from me.

***“I actually felt like I had my own chance to teach my own self, like be my own teacher, because I was learning things. When we would come back and say the information, you didn't even know some of the stuff too.”*** This quote was taken from Peter’s final interview. Many of my participants reacted positively to Sci-YAR especially because it gave them the freedom to be their own teachers and to learn from themselves and from each other. Michael agreed:

Michael: I like it because it gives us more freedom.

Me: Yeah, right? I think so too. Did any of the work you did impact you outside of school?

Michael: Yes, as I said it changed my opinion on steroids. Now I look at it as, I look at there's different types of steroids, it's not just one big group. That there's good steroids and bad ones.

As Michael explained, when students are given the freedom to be their own teachers, they are more likely to form better understandings of concepts. David agreed, “Going out and doing your own research, basically self-teaching, it gives me a better grasp on things. I like what you said there about doing your own research. The [textbook] represents

someone else's research." While the students were given freedom, they still were given guidance from me. Jerome recalled:

Everything was hands on. We were doing it ourselves. We had help from you but it was really on our own type of work that we had to get done and I think that was the best part about it. In other classes you normally have the teacher doing everything and they get to do all the fun stuff.

Sci-YAR requires that both teacher and students assume new roles in the classroom.

Teachers are the facilitators and the students are the doers – the experts. This does not diminish a teacher's position in the classroom, rather it dramatically impacts what a teacher and his or her students can accomplish. These interviews were conducted weeks and months after the school year ended, yet my students could still recall details about their research that they uncovered during their first few weeks of Sci-YAR.

Sci-YAR expects that teachers and students will trust each other enough to challenge and encourage one another to take risks. Peter explained, "I think that [trust is] important because you can do more things on your own than having the teacher telling you what to do all the time and you can have more freedoms." These freedoms and independence can foster skills within the students that can be transferred to other areas of the students' lives. As David explained, "If you want to find out to learn how to paint, and you're fifty, you can't really go back to school and learn how to paint. You have to teach yourself or work out ways to get started." Sci-YAR helped the students to realize that they have the knowledge and are capable of scientific inquiry without heavy supervision from their teachers. David explained that if he wanted to know something, he could rely on himself to figure it out. According to David, this ability to rely on oneself is something that will be used throughout his life. Self-reliance (or as my

students refer to as “learning from yourself”) is one of the more salient positive aspects of Sci-YAR. It demands trust, patience, and confidence from both teacher and students. It can also be transformative in how it allows students to learn what scientists do and act all while making learning engaging and meaningful.

In addition to freedom, many students cited reflection as a positive feature of Sci-YAR. Students are asked to reflect in a number of ways throughout Sci-YAR. They wrote weekly journals, documented themselves and their group as they conducted their research, and composed an essay at the end of the semester detailing their experiences with Sci-YAR and their individual research projects. For Keith, the reflection component helped to keep him focused on the present:

[The journals would] bring me back, to reassess what actually went on. Because I feel like you have all this information being thrown at you, and you can't really calculate it as much as- Just sit back and you know, what's going on, and what are the questions. Then it kind of makes you think of what actually is happening.

The Sci-YAR process spans approximately five months, and in that time, students have a tendency to get distracted and lose focus. Phil agreed with Keith in that reflection was a key component of truly comprehending their projects: “Once the project's done, you reflect on what you learn. If you don't reflect finally you're going to take this research project and learn nothing from it.” Both Keith and Phil needed time to reflect on their research in order to better understand their topics. Reflection also allowed students to gain perspective on their research leaving them with clearer ideas as to what they have already accomplished and what tasks they needed to prioritize.

Reflection not only helped students to focus on their particular research project, but also allowed students to gain a greater awareness of the research process. For



instance, Michael explained that reflection was a way for me to get to know my students and as a way for the students to get to know themselves. When I asked why they needed to get to know themselves, Michael answered, “Because if you write down something and then read it back, you're like, ‘Oh, I didn’t know I had these set of skills.’” For Michael, reflecting challenged him to realize that he was using scientific skills as part of his research. David had a similar experience. He explained that journaling helped him in the research process. “It got me to kind of express what I think about science, how I want to go about science, without just keeping it in my head.” Reflection was a way in which students could recognize the science knowledge and skills in the work they were doing as a part of Sci-YAR. It allowed them the space and the time to take a step back and examine their research topics and processes and to again connect their work with their lives.

***“In the beginning, it was kind of hard for people to figure out what was going on. Some people took it as a joke.”*** This was taken from my third interview with Michael. Many of my participants agreed with Michael in that Sci-YAR presented them with several struggles – one of which was the one that Michael describes above including the difficulty working with other students on such an intense project. This was Michael’s first time working in a group and he had difficulty keeping everyone in his group on task. Phil also encountered this issue. He stated, “I don’t like working with people.” Phil, like Michael felt that he did the majority of the work for his group: “I basically did the whole thing by myself. I would rather not have to divide up the work and know what I had to do and have a certain amount of time. If I'm relying on somebody

else and they don't get it done, I hate that. That's the things that makes me angry the most.” Regardless whether Phil and Michael did in fact do most of the work, it is their perception that they did. It is this perception that tarnished their opinions and reactions to Sci-YAR. Collaborating is a key feature of Sci-YAR and of good science teaching and learning and thus cannot be overlooked. However, helping all students to obtain ownership of their research and their learning, and therefore all contribute to the research in a true collaborative process, is a struggle that both my future students and I will face for years to come.

Many students not only struggled to work together but also struggled with the work-load that comes with balancing Sci-YAR with the more traditional topics of biology. Andrew argued that we spent too much time collecting data and that his group got bored. The data collection process lasted five weeks with one of those weeks occurring over spring break. While the students were in this phase, we would do data collection check-ins in which one to two groups presented on the data they have already collected and their plans to collect the rest. These check-ins were usually once to twice a week. The remaining class days were devoted to traditional topics such as the plant and animal kingdoms. While Andrew stated that his group was bored during this phase, David and his group struggled to move back and forth in between topics. “I was confused because I was still caught up on the [ALS research] stuff. Then we had to learn about certain plants and all that, so I was really confused.” Sci-YAR challenged students to not only manage their specific research projects, but the normal demands of the course such as tests, quizzes, homework and labs. Balancing these two aspects of the course can be

overwhelming, but managing course work, time and expectations are life skills that are taught implicitly within the Sci-YAR framework. Table 2 illustrates an actual month's lessons during Sci-YAR's implementation.

A few of my students wanted more structure and guidance from me. Keith mentioned that in order for a group to be successful, "it's easier for everyone to pitch in." Keith continued stating that I could better facilitate the process of gaining equal participation of all students: "I feel that's another thing that maybe you should enforce everyone to work together. I mean I had no problems doing most of the work, but I'm pretty sure [other students] had some problems doing a lot of the work." Andrew agreed that when I transferred some of the control to the students, many struggled with staying focused and looked to me for more assistance:

Andrew: [Students] can get so sidetracked. Sorry but [students] can get really sidetracked in your class.

Me: Why?

Andrew: Because you're sort of laidback.

Me: Yeah.

Andrew: You really don't. I'm sorry to say this.

Me: Don't be sorry.

Andrew: You really don't lay down the law.

Me: I don't.

Andrew: No. You're really bad at getting people's attention. Yeah. You're horrible at that.

The traditional science classroom places the teacher at the center of control. My students had difficulty placing themselves at the center and wanted more direction and intervention from me. Directing their own learning was a new concept for my students and they experienced difficulty and confusion with it throughout the semester. Sci-YAR challenged students and teachers to rethink traditional roles in the classroom. This challenge can be a difficult one through which to work, but the end result of students explaining their own research with confidence is well worth any and all preliminary struggles.

Additionally, Andrew gave my classroom management practices some constructive feedback. Andrew implicitly asked that I give the students more structure and deal with those students who lose focus and present class distractions quicker. Moving forward, I will take Andrew's feedback and use it to better my instruction in future implementations of Sci-YAR.

**Research Question 3c: How does Sci-YAR affect other areas of my students' lives?** Just as Sci-YAR influenced my life outside the classroom, it also impacted my students' lives as well. For some of my students it changed the way in which they viewed and understood their research topics. For others it allowed them to gain a greater awareness of a subject that was deeply personal and meaningful to their families and communities. Lastly, many students explained how they were able to transfer their research skills used in the Sci-YAR projects to their lives beyond the classroom.

*"I feel like that a lot of people actually are listening and watching what I'm doing. I have juniors and seniors that are my friends, so no one wants to hang out with*

*the immature kid.*” Jerome made this comment to me during our last interview. Jerome explained that Sci-YAR made him feel like his voice was heard and that he now realized that people are paying attention to him. This realization has allowed Jerome to see himself as someone important, who people will notice, thus he wanted to be viewed as someone mature and intelligent. Jerome also explained how he uses the research skills he acquired in Sci-YAR to make him a better athlete. For Jerome, research was about breaking down a topic into steps. “When you think about things, you want to break it down in those steps to think about it.” He continued to use this research method while on the football field:

I use [research] a lot. Especially playing linebacker now. You have to be visually ready for everything. You have to watch what the guard is doing, you have to watch the quarterback, you have to watch the running back. You have to make sure a line is set up where they're supposed to be. You have to communicate with your partner, the other linebacker next to you. You have to break it down like that.

Breaking down concepts into steps allowed for Jerome to be a better researcher and a better athlete. During Sci-YAR, we broke many concepts down into smaller steps from choosing a topic, to designing a research plan, to analyzing data. Jerome and his group were able to handle these challenges with ease, which explains the clarity in which Jerome discussed how he used his research skills as a starting linebacker on the football team.

Phil was also used his research skills during football season, not as a player but as a trainer. “If you’re watching somebody get tackled and you see their back twist weird or you see an ankle roll really weird or if you see something happen, that's a quick observation where you got to know what to do on the hop.” Phil was able to develop his

observation skills while he researched spiders in my class. Phil always thought of science as hands-on and did not consider observing an active part of understanding science. As part of his spider research, he and his group needed to keep a daily log of observations. While Phil admitted that some days they were not recording any changes to the spider behavior and he would get bored with taking observations, he now realized that the ability to observe is a key component of his role as athletic trainer – a position he plans to explore further in college.

For two of my students, Bob and Keith, their research skills have helped them solve everyday problems. Bob stated, “It helps look at things differently and try to look for another solution to a problem.” Keith explained a specific instance of how he used his research skills to problem solve this past summer as he traveled to different parts of the country. He began, “[The] Action Research Plan, I can probably use that in any situation.” When I asked for an example, he stated “We ask[ed] ourselves how do we get to Portland? [In] Tennessee – where we stay so then that's our question. We look[ed] at the research and on our GPS and said how do we get there and what's the best way to get there”. Keith explained how he used the research steps from choosing a topic (or destination), asking a question (how do we get there?), and conducting research (by exploring different routes) to travel to Portland and Tennessee. For many of my participants, research skills do not exist solely in a science classroom, they are present in everyday situations illustrating again the impact of Sci-YAR on my students well after the class and the research projects are completed.

**Research Question 4**

How does engaging in Sci-YAR impact me and my practice as I move forward in my career?

I have never been one who plans out her career in detailed five and ten year plans. I have taught at schools until my teaching started to become stagnate or because another interesting challenge was presented to me. Considering my future career goals in the context of Sci-YAR and its impact on these plans, was a new endeavor for me.

**“My ultimate goal would be to increase student voice and ownership and happiness amongst students and teachers.”** This is a quote taken from a journal entry written on May 26, 2014. This excerpt is from the end of the semester, thus I have just successfully completed another semester of Sci-YAR. I am reflected on the entire process and the most salient components of Sci-YAR are the excitement and ownership it brings to my students. Year after year, I have seen the joy that exudes from my students on the day of the Research Symposium. This joy is contagious and is something I want to maintain.

Moving forward, “I would work to extend the tenants of Sci-YAR to every science class. I would also work to implement these tenants into the other classes while educating the teachers on Sci-YAR” (written journal, May 26, 2014). Sci-YAR can be implemented in all levels of k-12 science, but requires collaboration among teachers to do so. My future career plans involve being in a position in which to work with students and teachers to make this goal a reality.

“I want to stay at [my current school], assuming the role of Curriculum Director. I would teach two classes (AP Bio and Bio). I would then assist the departments in curriculum mapping” (written journal, May 26, 2014). I have always been reluctant to verbalize my future career goals, because there is a part of me that doubts my ability to handle administrative responsibilities. Sci-YAR has given me the confidence and courage not only to state my future intentions but also to begin the conversation with my principal to put these plans into place. While staying at my current school in a more administrative role is one career possibility, Sci-YAR has taught me to be open and accept the unexpected. I am staying open to any and all opportunities that allow me to work with teachers and students in making science teaching and learning more engaging and meaningful.

In addition to seeking out new responsibilities, Sci-YAR has also changed my role in these future career plans. It is no longer about the title or the job description, it is about the change I can make:

I also view myself as an advocate for my students and parents. I always thought of myself as this in some capacity; but before I saw myself who advocated in my own small way - in my classroom with my students. Now I view myself as an advocate who can (and will) fight for my students on a larger scale. I feel completely comfortable voicing my opinion at faculty meetings or in smaller conversations even if it means that I disagree with other teachers especially those who have been around a lot longer than I have. I also see myself as an advocate for my fellow teachers (written journal, May 11, 2014).

Regardless of where Sci-YAR takes me, one thing will be certain. I will be fighting for meaningful science education opportunities for students, their families and my fellow teachers. Sci-YAR has allowed me to prioritize my goals and the things that make me love teaching science. One of my favorite things is that moment in which students who



have been struggling with a concept or process finally understand it. Another is when my students rush into my class because they are so excited to learn or when I hear from a parent how proud they are of the work their son is doing. These are the things that must be part of my future career.

### **Summary**

This study sought to better understand how my students and I make meaning of our experiences while engaging in Sci-YAR. This study was comprised of a self-study that began in January of 2014 and a phenomenological study that began in June of 2014. The self-study consisted of written and audio journals as well as a content analysis of my science curriculum. The phenomenological study included eight participants who were all former students of mine. I interviewed each participant three times.

I uncovered that my teaching has been transformed over the past four years. I have the courage and the confidence to challenge the power structures in my classroom and in my school and to rethink what good science teaching and learning looks, sounds, and feels like. I am open to discovering what my students think about my teaching and I continue to investigate ways to make my science teaching more responsive to my students. I also was able to change my role in the classroom from the keeper of knowledge to the facilitator of knowledge. This also required a fair amount of courage and trust in myself as an educator and in my students as learners. By changing the locus of control from me to my students, my passion for teaching has been re-ignited.

This study also allowed me to realize what I have learned about myself as a teacher and about my students while engaging my students in Sci-YAR. Throughout this

process, I discovered that I can still feel like a successful educator despite the ever present doubts and fears that will creep into my consciousness. I also came to an appreciation that no matter how many years I have been teaching, my students will surprise me. This is not a weakness on my part, but rather an aspect to teaching that should be celebrated. Regardless of how confident I might be in my ability to know my students, they will show me a side of themselves that I was not anticipating. Last, Sci-YAR has impacted me outside of the classroom. Sci-YAR has given my teaching a purpose. This has, in turn, made me a nicer, happier and more fulfilled person outside of the classroom and has strengthened my relationships with my friends and family.

My students also made meaning regarding their experiences with Sci-YAR. While engaging in Sci-YAR, my participants learned about themselves academically, as experts, as leaders, and as scientists. While at times, they struggled to call themselves “leaders” or “experts”, they were able to explain how they acted as leaders and as experts with ease and confidence. Similar to myself, my participants had some varied reactions to Sci-YAR. Many enjoyed and appreciated the freedom they experienced in making decisions about what they wanted to learn and how they wanted to learn it. Some participants were uncomfortable and overwhelmed with the control they were given and desired more structure from me. Others had difficulty balancing their research with the other demands of the course. Many participants also experienced the impact of Sci-YAR outside of the classroom. They explained how they used their research skills, which were first developed through Sci-YAR, in their other classes and the other aspects of their life.

Sci-YAR has not only challenged my students and me to think differently about science teaching and learning, it has allowed me to think differently about my future career ambitions as well. Through the development and implementation of Sci-YAR, I am able to successfully take risks in doing so I am able to reposition myself in my role in the school community. This repositioning has challenged me to consider how I can use the skills developed through the Sci-YAR process to move my career forward and to make science teaching and learning more meaningful to students and teachers alike.

## CHAPTER V

### DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

#### **Overview**

This chapter provides a summary of the key highlights of the study, a discussion of the findings from Chapter IV, and implications for practice for K-12 teachers as well as for science educators. Recommendations moving forward are also discussed along with plans for future research.

#### **Key Highlights**

A few significant features of this study include an increased awareness of how students and teachers make meaning of their experiences in the same classroom while experiencing Sci-YAR and a greater understanding of a unique curricular framework and its impact inside and outside of the classroom. Sci-YAR challenged both my students and me to rethink what science teaching and learning looked like, sounded like and felt like. This study offers a glimpse into one teacher's classroom who is attempting to make science more engaging more meaningful for her students and herself.

This study also addresses the gaps in science education research in a number of ways. It is rare for an in-service teacher to conduct research in her own classroom involving her students as participants. This study gives an emic perspective of that of an in-service teacher and of the students in the class – a perspective that is largely absent from science education research.

Science education is currently failing our students, especially those students who do not identify as being good at science (Emdin, 2009). Many students remain disengaged in the science classroom and even fewer students are pursuing science-related careers upon graduation. Researchers and educators have ideas on how we can tackle this issue, but they mostly address this issue from an outsider's perspective. Student and teacher voice needs to be strengthened and made part of this conversation in order to gain a greater understanding of the issues facing science education today as well as to devise effective solutions that include all stakeholders.

Engaging in a self- study and a phenomenological study of students' experiences has afforded me greater insight into my teaching and my students' learning. While my findings might not hold true for every teacher in every classroom, they do hold true for one teacher in one classroom. Additionally, the methods used in this study could be applied to other teachers in other classrooms, thus providing an accurate picture into the daily routines and struggles of science teachers and their students.

### **Discussion of Findings**

Some of the main themes that arose in Chapter IV were centered on the ideas of control, position, and challenging the status quo. These themes were the most salient because they represent the similarities between my participants' reactions to Sci-YAR and my own reactions to Sci-YAR. Despite occupying different roles in the classroom, we still found ourselves struggling with certain issues and gaining awareness of particular aspects of Sci-YAR's impact on our lives.

### **Taking More Control**

Both my students and I struggled with the issue of control. I was nervous about surrendering control as it ran contradictory to what I was taught about teaching. I always knew I was unable to actually control other people, but I was taught that, in theory, if you are a good teacher, you could “control” your students. Sci-YAR gave me the foundation to relinquish control and to place learning at the center so I could teach in way that I knew was going to best serve my students.

My students, on the other hand, appreciated that I was able to allow them to control their learning. Jerome recalled the following during our third interview:

Me: How did you feel, because a lot of the decision making was on you? How did you feel about making all these decisions?

Jerome: It actually felt pretty good to be empowered to control everything. We had some guidance from you and Mrs. Coleman, but for the most part we basically did everything on our own.

Me: Have you ever had that experience before in a class?

Jerome: Not in the classroom.

Me: No? Where have you had it otherwise?

Jerome: On the football field.

Students want to feel empowered; they want to be in control. Jerome is like many of my students in that school is what he must to in order to engage in activities that truly interest him – such as football. Jerome enjoyed activities that afford him control which explains why for Jerome and many of my students athletics is more interesting than academics. We should be making our science classrooms look more like spaces where youth are

engaged, such as on the football field. Giving students control is a great way to achieve this.

Keith felt the same way that school was a means to an end, not an end in itself. For Keith, the meaningful work occurred after school and on the weekends when he would watch Neil deGrasse Tyson lectures to engage his curiosity. It is a sad occurrence that students need to leave the classroom in order to feel in control and engaged. Both teachers and students want more control over what they study and how they explore new learning. The teacher must be able to trust herself and her students to surrender control and to put her students first despite feelings of discomfort and concern.

Critical theory challenged me to explore these issues of control in my classroom and gave me the foundation and the encouragement to do so. Giroux (1997) argued that education should be liberating. This liberation can occur when teachers are no longer at the center of instruction. Sci-YAR requires that the locus of control shift from teacher to student. The students become the main decision makers. This shift allowed my students to become liberated as they experienced freedom in their learning experiences. My students became excited to come to class and to express themselves through their research. I also experienced this liberation. No longer was I in charge of my students. We became partners. We got along better. My interactions with my students were no longer confrontational. I was able to support them and encourage them – and they trusted me because I gave them choice and treated them like experts.

This shift in control is also reflective of the nature of science. As stated earlier, the nature of science guided the development of Sci-YAR. Lederman (2007) argued that

students often times are not exposed to the creative and human components of science. By transferring control, students were able to express their creativity in the science classroom. For instance, Keith is a talented artist and his presentation included an illustration he did based on a Neil deGrasse Tyson quote about scientific discovery. Andrew and Bob's group explored the human and subjective nature of scientific inquiry. Both Andrew and Bob mentioned in their interviews a time in which their group did not agree on how to conduct their focus group during their research. Both participants mentioned that they solved any disagreements through discussion and consensus building. Not once was I called over to referee their disagreements. I was also reminded of the creative and human aspects of science knowledge through my students. My students would often surprise me with their ideas, plans and findings reminding me again that surrendering control allowed them to gain greater awarenesses of how scientists actually do science.

### **Changing Roles**

Another similarity between my participants and me was that we struggle to see ourselves as leaders. Andrew explained his hesitation with identifying as a leader was due to the fact that he tended to "goof off" in school and was not the captain of the hockey team. I can empathize with Andrew in that I struggle to see myself as a leader because I also do not feel as though I am skilled or experienced enough to be considered a leader. I still have so much to learn, I sometimes doubt my ability to be seen an instructional leader among my colleagues.



Despite these doubts, I have managed to position myself as a leader starting with the science department. I knew that my students both past and present were not getting the science education that they should. With them as my motivation, I sought out and secured the position of science department chair this past 2014-2015 school year. My first few years working at my current school were difficult and I did not feel as though I belonged especially considering that colleagues within the science department failed to support my students or me in our Sci-YAR projects. There is a long way to go with my department, but now as the department chair I am in a position to enact greater change.

Just as I changed my position in the school, my students also found that Sci-YAR helped change their position in the school community. Giving the students authentic science learning experiences and positioning them as experts allowed them to change the way in which they viewed themselves and how they felt they were perceived by others. Jerome discussed this change in position as he recalled people's reactions to his presentation at the Research Symposium:

I felt as [though] people were coming past [and] looking at it like, "These guys aren't serious." You could even hear them talking about it. But then [when people actually got to our presentation and saw] what we were actually talking about, they were pretty amazed. I felt very proud of myself and Peter because we actually pulled it off. It wasn't a joke. We really got some good research. We also got some good feedback from the parents, even some of the teachers, even teachers I had problems with, with the school year.

Jerome sums up his experience with Sci-YAR as "it felt good to be a teacher." It also felt good for me as their teacher to experience my students changing their position in my classroom. According to the National Research Council (2000), teachers need to be positioned as guides in the classroom in order to assist their students with discovering

scientific understandings. Bransford and Donovan (2005) agree that in order to help students in understanding science we as educators must be attuned to the students' ideas and thinking. By positioning the students as experts, and the teacher as facilitator, the students' ideas and thinking become the center of instruction – not the teacher's ideas and thinking.

The changing roles that my students and I experienced in the Sci-YAR classroom help to focus on what Sandoval (2005) calls practical epistemologies. Practical epistemologies are centered on what students know about the construction of their scientific knowledge as opposed to someone else's knowledge. By making science relevant and positioning the students as researchers and as experts they gained greater awareness of how scientists do science through their own experiences rather than by reading about someone else's experiences.

Jenkins (2006) argues that listening to students will increase their motivation in the science classroom. I argue that listening to students also increases teacher motivation in the classroom as well. Just as my students were excited to come to class, I was equally excited. I loved sitting down with each group and discussing their ideas and their research letting them guide the conversation. I realized through this study, that the Trackton boys that Brice Heath (1983) described were my boys. Both were empowered by science and were challenged to think bigger and to become the experts and the students that they never thought they could. With regards to my changing role outside of the classroom, this experience is what made me love teaching science again and what has encouraged me to seek out leadership roles. Seeing my students engage in science

learning gives me the confidence to take Sci-YAR's approach to science teaching and learning and to see where else it can inspire students and teachers.

### **Challenging the Status Quo**

The purpose of critical theory is to challenge the status quo (Kincheloe & McLaren, 2003). Critical theory guided my research and my instruction for a number of reasons. First, I wanted to empower my students through their Sci-YAR projects. Critical theory supports the empowerment of students and views this act as necessary. Critical theory argues that the purpose of education is to free individuals and their thinking, to liberate the oppressed and to empower students (Giroux, 1997; Pinar, 2004). Second, I wanted to place myself at the center of my research to better examine the factors that were limiting my students and their thinking in order to empower them.

As I read back over my memos written after my participants' interviews this summer, I noticed that my participants mentioned feeling bored in class. The status quo was evidenced in students' boredom with school and this was an issue even in my own teaching. Sci-YAR helped you combat this boredom by giving the students' choices and allowing them to take ownership of their learning. Below is an excerpt from my first interview with Jerome:

Me: Do you find yourself getting bored a lot?

Jerome: Sometimes. In most of my classes I got bored.

Me: Yeah? Why?

Jerome: They weren't like you. Your class was so amazing.

Me: Oh my God, say that again louder. I'm just kidding.

Jerome: Every day your class was the best class ever. Even if I was getting yelled out, it was still the best class ever.

Me: Do you know what's funny, Jerome? I can't remember why I even yelled at you.

Jerome: I do. I used to get out of my chair every day.

I interpreted my participant feeling bored as them not being appropriately challenged or even worse being treated like children. My participants discussed at great length how in their other classes they were expected to stay seated, take notes, and read from the textbook. It appeared that they were not at the center of teaching and learning. Many participants like Jerome and Peter would disrupt class as a way to combat the boredom.

Challenging the status quo means giving all students the opportunity to feel appropriately challenged; to forgo the more traditional (and at times easier) approaches to instruction; to let things feel chaotic; and to take risks. One of the positive impacts of challenging the status quo, which is that some students felt smart, important, and part of a community of learners. Keith discussed his feeling smart with an excerpt from our last interview:

Me: How did you feel when you were connecting your research?

Keith: Awesome. Because I never had, a lot of kids only have the chance to actually do the research, have that importance. Because I really like, when we did the interview, I felt like I got in here with a bunch of smart people.

Me: And you're one of them.

Keith: Yeah.

Me: And you're one of those smart people. You're having a smart person conversation.

Keith: Yeah. It's just because you're kinda, me especially because I was surrounded by people that really care about this subject as well.

Sci-YAR supports Freire's (1970) argument that the banking model approach to education is not effective in inspiring students to become critical thinker or life-long learners. I had to take the risk and rethink how I taught in order to examine this banking model and to challenge it. I doubt that Keith would have felt this smart if I had relied on traditional methods often supported by Freire's banking model.

The above excerpts involving both Keith and Jerome also include the exchange of feedback and support. Jerome supports me by informing me how meaningful he found my class and I offer support to Keith by validating him as a student. These are just two examples of how Sci-YAR confronts the status quo by changing the dynamics between student and teacher. Challenging the status quo and the banking model through Sci-YAR impacted both my students' and my attitudes towards ourselves and our roles in the classroom.

Additionally, power structures exist in the classroom. These power structures can manifest themselves in students' social interactions in the classroom, which can, in turn, impact how students learn (Barton & Tan, 2010). I challenged the status quo by thinking differently about my teaching and having the courage and the inspiration to place myself at the center of my research. If I was to truly explore the issues of power and control, which could be a factor in my students' ability to learn in my classroom, I needed to become not only the subject but the researcher as well.

## **Implications**

The purpose of this study was to examine my experiences and my students' experiences engaging in Sci-YAR, to empower myself and my students through research, and to give an emic perspective on teaching science and on implementing an innovative curriculum. By exploring these facets I generated several implications for classroom teachers and for the future of science education.

### **Implications for Teachers**

Examining one's practice allows for teachers to better understand and improve their own teaching (Pine, 2009). Self-study is one way in which we as teacher can systematically explore our practices and the beliefs, values and experiences that helped shape it. By engaging in self-study we are able to assess our progress in the classroom, uncover inconsistencies between our practices and beliefs, and to challenge our thinking (LaBoskey, 2004). I engaged in self-study in order to better understanding my experiences as I engaged my students in the Sci-YAR curriculum. I knew that I needed to challenge myself to transform my teaching to make science more accessible and engaging for my students. I also wanted to strengthen my voice as a classroom teacher by gaining a deeper awareness of how I am connecting with my students through my instruction, and also by sharing my experiences with interested readers.

Self-study can be transformative. The systematic reflection, often accomplished through self-study and other types of practitioner inquiry, can be emancipatory and can help teachers to better understand how their ideas and actions can positively impact their homes, schools, and communities (Carr & Kemmis, 1986). In addition, self-study can

result in teachers challenging themselves to explore practices outside of their comfort zone and to grow as a teacher, a researcher and an individual (Coleman & Leider, 2013).

Self-study provided me with meaningful professional development. I have the confidence to take risks, to challenge my students, and most importantly, to make mistakes. I would like this study to serve as a model for teachers who wish to further their own practices by looking at who they are in the classroom and what factors guide the decisions they make. I argue that most teachers want to become better. Self-study challenges teachers to become better by highlighting their strengths and their areas for improvement, but by more importantly encouraging teachers to take risks and to rethink our views of teaching and learning. It was only when I was able to look at my practice at a distance was I better able to understand it. This would not have been possible without self-study

Additionally, hearing my students describe their experiences to me through our interviews, has made it clear to me that teachers need more latitude in the classroom. I have been fortunate in that I have had the trust of my administrators and the space in which to take risks in my classroom. One of the many reasons, I choose to teach in Catholic schools is that I am given the freedom and encouragement to design my own curriculum. Sci-YAR has been able to be transformative because I am not burdened by test scores or pre-determined curricula like so many of my science teacher counterparts.

### **Implications for Science Education Research**

Science is a way of knowing: the ways in which scientists collect information through scientific investigations and then form conclusions (Coleman, 2014; Crowther et

al., 2005; Lederman et al., 2002). Since science is really a way of gathering information, and not the information itself, as a teacher, I need to work on helping my students understand that they can be experts in doing science without necessarily knowing everything about science. Educators need to stop teaching science as a bunch of facts or the simple application of facts through predictable lab exercises but rather as a set of skills that anyone can do.

Science does need to become more accessible to all students. Unfortunately traditional science teaching methods are often times inconsistent with how scientists go about their work and also with how students learn science (Bransford & Donovan, 2005; Windschitl et al., 2007). Sci-YAR offers a solution to the issue of accessibility. Sci-YAR engages students in collaborative action-based scientific inquiries that are rooted in issues of great importance to the students (Coleman, 2014). Since Sci-YAR is a curricular framework and approach to instruction, it can be implemented at any time in any subject area in any grade.

Moving forward, one of the more profound implications I have for this study is to engage our students in discussion about their experiences in the classroom. While I used a phenomenological approach to investigate my students' lived experiences as students in my classroom, this need not be the case. I was so impressed with the clarity and ease in which my students explained their experiences in my classroom to me. They were open and honest and did not hold back in the least. I heard some great things, some not so great things and everything in between. Our students could be our best teachers in



designing meaningful learning experiences that engage, inspire and challenge them if we are courageous and humble enough to do so.

The last implication focuses on the unique nature of this study. I am currently unaware of another study that involves a practitioner's self-study alongside that of a phenomenological study of her students. In this study, my participants acted in many ways as my critical friends validating and challenging my assumptions and findings. This study could serve a model for K-12 educators for also for any individual or individuals in relationship based professions (social worker, manager, etc.) seeking to better understand their practice.

### **Recommendations for Future Investigations**

The first recommendation for future investigation is to encourage other teachers to engage in this type of inquiry – either self-study or phenomenology. This work is difficult to conduct alone. I argue that this type of work can and should be done in community. We as teachers and as researchers need to rely on each other. By forming a community of teacher-researchers we can lend support, offer our critical friendship, and give meaningful feedback to one another.

The second recommendation would be to replicate the study again with the group of students from the 2014-2015 school year and compare their experiences with the participants of this study who were students in my class during the 2013-2014 school year. Every class has its own personality. Comparing the feedback from my current students to the participants in this study would allow me to better understand the variety

of students' experiences with Sci-YAR. I often wonder if the themes highlighted in this study are an anomaly or are true for most students engaging in Sci-YAR.

I would also like to spend more time analyzing each participant and how they changed throughout the course of their experiences with Sci-YAR. I have so much data on each participant and during my analysis; I began to see how certain participants changed over the course of the semester. One recommendation is to focus on each student as his own case study more in depth in order to better understand their specific experiences with Sci-YAR.

Last, in the future, I would like to form a community of researchers comprised of both teachers and students. I experienced my students acting as my critical friends throughout this study. Ideally, I would like to get them more involved in the research process by positioning them as experts not only in the classroom, but of their own learning experiences as well. My students could offer invaluable guidance to my research design and findings. Based on the interviews with my participants, I am keenly aware that they have the confidence and desire to give thoughtful feedback regarding their experiences in the classroom and in the school.

### **Summary and Final Words**

In my 13 years of teaching and my five years of researching, it has become clear that the science education community can do more for our students. Many students who do not identify with being scientists are capable of authentic scientific work. Our students want and deserve to engage in meaningful science learning experiences.

Connecting scientific inquiry to students' lived experiences opens up an entire universe of teaching and learning that teachers and students can explore together.

Through the course of this study I have found that my students and I are quite similar. I would argue that we both became empowered through our engagement with Sci-YAR. By exploring our experiences with this curriculum, we were able to give and receive more control. Although scary at first, we worked together and trusted each other enough to create a learning environment that supported our needs. We also were able to strengthen our voices as teacher and as students which is too often neglected in science education research. I sought out to give an account of my classroom from multiple perspectives and in doing so to demonstrate the transformation that can occur when we take risks and view science and not something we know, but as something we do.

APPENDIX A  
SELF-STUDY JOURNAL PROMPTS

## Journal Prompts

1. Describe my teaching before Sci-YAR was developed
2. Why is it important for me to include Sci-YAR in my instruction?
3. How did developing and implementing the Sci-YAR curriculum impact other areas of my life professionally and personally?
4. What elements of the Sci-YAR curriculum are the most meaningful to me?
5. What are my initial reactions while engaging my students in the Sci-YAR curriculum?
6. What are some successes I am experiencing with implementing the Sci-YAR curriculum and how do I determine what success looks like during this curriculum?
7. What are some struggles I am are facing with implementing the Sci-YAR curriculum?
8. What are some obstacles I have faced in changing my instruction to include Sci-YAR?
9. How do I feel when I am engaging the students in Sci-YAR?
10. What am I learning when they experience instruction Sci-YAR?
11. How does teaching the Sci-YAR curriculum continue to impact other areas of my life – professionally and personally?
12. How has the development and implementation of the Sci-YAR curriculum changed the way I view myself?
13. How did this year's cycle compare to last year for me? For the kids?
14. How has my teaching objectives and personal satisfaction changed over the years?
15. What are my future plans and how will I move forward with Sci-YAR in the future?

APPENDIX B  
CONTENT ANALYSIS PROTOCOL

## Science Curriculum Content Analysis Protocol

Content (circle one)      Sci-YAR Curriculum for School Year \_\_\_\_\_

Lesson plan (Daily agendas)      Unit plan

Description: \_\_\_\_\_

***Key Features of Sci-YAR*****I. Science is a way of knowing and taking action**

- A. Instruction, discussion, and reflection related to these essential questions as the students conduct their research and develop a plan for future action based on the findings of their research.

- What is science? Who are scientists?

Present in document \_\_\_\_\_

Evidence:

- How do scientists work together to answer questions and solve problems?

Present in document \_\_\_\_\_

Evidence:

- How can we generate and communicate scientific knowledge for the benefit of others?

Present in document \_\_\_\_\_

Evidence:

- How can science be used as a tool to help address areas of concern in our city, community, and/or neighborhood?

Present in document \_\_\_\_\_

Evidence:

## **II. Participating in relevant practices of science through action research**

- A. Students are introduced to action research and are given the opportunity to explore connections they see between scientific inquiry and action research.

Present in document \_\_\_\_\_

Evidence:

- B. Students engage in instruction, discussion, and reflection on how they already use scientific process skills in their own lives, and how they might use these skills to conduct research that benefits others.

Present in document \_\_\_\_\_

Evidence:



- C. Students select and research their own topics related to their lived experiences.

Present in document \_\_\_\_\_

Evidence:

- D. Students develop their own definitions of what constitutes scientific research, and they use criteria negotiated among themselves (and the instructor) to design, conduct, and critique research.

Present in document \_\_\_\_\_

Evidence:

### **III. Engaging in extensive personal reflection**

- A. Students engage in self-documentation throughout their participation in the curriculum, selecting whatever medium (or media) they prefer, such as writing, art, photography, film-making, blogs, or other social media.

Present in document \_\_\_\_\_

Evidence:

- B. Students keep an ongoing reflection journal where they reflect on ideas presented or generated during the research process, as well as their experiences engaging in the curriculum.

Present in document \_\_\_\_\_

Evidence:

- C. Students periodically analyze the data they collect throughout their self-documentation and journaling to make assertions about their personal growth and the development of their practices of science throughout the research process.

Present in document \_\_\_\_\_

Evidence:

- D. Students engage in self-assessment as a component of their data collection.

Present in document \_\_\_\_\_

Evidence:

#### **IV. Collaborating through collective research**

- A. Students dialogue with peers in the class to discuss how their issues of interest might be related, and youth form research teams based on common interests.

Present in document \_\_\_\_\_

Evidence:

- B. Students work in teams to develop research questions and a research plan, and they execute that plan, including data collection and analysis, as a team.

Present in document \_\_\_\_\_

Evidence:

- C. Periodically throughout the research process, teams present their research plans, the progress they have made on data collection, and their preliminary findings to the class. The class (including the instructor) provides teams with brief oral feedback, as well as written feedback in the form of peer assessments that offer suggestions for each team's research. Teams are encouraged to incorporate the feedback they receive as they move forward with their research.

Present in document \_\_\_\_\_

Evidence:

**V. Conducting research that is youth-generated and youth-led**

- A. Youth select their own topics, generate their own research questions, and develop research plans with data collection and analysis procedures that they select.

Present in document \_\_\_\_\_

Evidence:

- B. Youth take the initiative to seek out sources and develop tools for data collection. This may include: designing interview protocols and finding participants to interview; developing and distributing surveys; designing

controlled tests; finding detailed and accurate ways to observe and/or measure phenomena related to the topic under investigation

Present in document \_\_\_\_\_

Evidence:

**VI. How has the student learning outcomes and objectives changed each year? (Unit/Lesson Plans only)**

APPENDIX C

DATA COLLECTION TIMELINE

## PLANNING TIMELINE FOR DATA COLLECTION

Data Collection Due Date --&gt;

August 25, 2014

Key Event	Time Frame	Key due date	x	Comments
1 Get IRB approval	10/1/13 to 12/15/13	December 15, 2013		Due to the practitioner inquiry component to the study that requires me to conduct research in my own classroom, IRB might prove to be a challenge.
2 Finalize document analysis protocols & journal prompts	10/1/13 to 12/15/13	December 15, 2013		The pre-determined journal prompts will be a guide to my written journal entries. New prompts can always be added.
3 Begin Self-Study	1/6/2014	August 25, 2014		
4 Take audio recordings of reflections	Weekly	August 25, 2014		Add to express scribe once a week to keep on top of organizations & analysis
5 Written journal entries-	Weekly	August 25, 2014		Use the journals and recordings to inform
6 Document analysis of curriculum-unit plans	Monthly	February 28, 2014		Use critical friends to assist in the analysis of the curriculum
7 Recruit participants	2/20/14 to 4/15/14	June 6, 2014		Distribute information regarding study as well as informed assent and consent letters to students to be returned in a sealed
8 Document analysis of curriculum-lesson plans & daily agendas	Monthly	April 30, 2014		Use the document analysis to inform interview questions & journal entries
9 Finalize Phenomenological Protocols	5/1/2014 - 6/2/2014	June 2, 2014		
10 Begin Phenomenological Study	6/2/14 to 8/25/14	June 2, 2014		
11 Finalize participants	6/2/2014	June 6, 2014		Elizabeth will give me the participant list
12 Interview #1	6/9/14 to 6/19/14	June 19, 2014		Interviews should be at least one hour in length
13 Interview #2	6/23/14 to 7/3/14	July 3, 2014		Each interview should be 4 days apart
14 Interview #3	7/7/14 to 7/17/14	July 17, 2014		Send interview data out for transcription asap
15 Document analysis - student journals	Weekly	August 25, 2014		Being the document analysis by June 6th to inform interview questions
16 Document analysis - final projects	Weekly	August 25, 2014		

APPENDIX D

STUDENT JOURNAL PROMPTS

## Student Journal Prompts

1. What do you hope to get out of your research project? What are three goals you have for the project (for instance maybe you want to increase your knowledge of something or develop your interview skills). What are you excited about? What are you nervous about? Answer using complete sentences and feel free to illustrate your answers as well.
2. Describe a memorable event in your life that has helped make you the person you are today. Include in your description:
  - What the event was
  - When it occurred
  - The key people involved (in addition to yourself)
  - How this event impacted you as a person
  - Why this event is still so memorable for you today
3. State the topic you will be researching. Why did you choose this as your topic? How do you feel about researching this topic for the next few months?
4. Begin class with a journal: Looking at the documentation you produced, answer the following questions:
  - If someone who didn't know you looked at these artifacts, what would that person say about you?
  - How has your research influenced you as a person so far? (If you don't think that doing this project has influenced you, then talk about why you don't think it has.)
5. You are now in the middle of creating a plan for your research. What are some plans you have made for yourself after high school? Why do you need to make those plans? What would happen if you didn't make those plans? What would happen if you didn't make a plan for your research? Answer using complete sentences and feel free to illustrate your answers as well.
6. What is an expert (how would you define "expert")? What kinds of things do experts do? What do they look like? How do they act? Would you agree that you are an expert on your topic? Why or why not? How do you feel when you think of yourself as an expert? Answer using complete sentences and feel free to illustrate your answers as well.



7. *Honestly and seriously* reflect on the work your group has done on your action research project over the last couple of months. Describe the following:
  - The role you have played in your group so far (i.e. leader, follower, information finder, organizer, slacker, etc.)
  - How the role you have played has helped/hurt the group's efforts
  - A group accomplishment that you are most proud of
  - An area your group needs to improve in
8. *Honestly and seriously* reflect on the work you have done on your action research project over the last couple of months:
  - What positive things do you think you have done to contribute to the project? In other words, what are you most proud of so far?
  - What not-so-positive things have you done to prevent the group from making progress on the project? In other words, what areas could you work on to improve your performance in the group?
9. How do you feel about working on this action research project (i.e. interested, nervous, excited, bored, confused, successful, happy, etc.)? Are your feelings changing as you work on different parts of the project? Give examples that illustrate why you are feeling the way you do.
10. What parts of the action research project have you enjoyed? Why did you like them?
11. What parts of the action research project have you disliked? Why did you dislike them?
12. What parts of the action research project have confused you? Is there anything you would like Ms. Leider to help you better understand?
13. Review your definition of science (written in a prior journal entry) and make any changes to it based on the experiences you've had in the past couple of weeks. What do you think science is now?
14. Compare and contrast how scientists do their work and how you have worked to formulate your own research questions for this project.
  - a. How is a scientist's work similar to what you are doing?
  - b. How is a scientist's work different from what you are doing?
15. Did you use creativity and imagination during your research?
  - a. If yes, at which stages of your research did you use your creativity and imagination?
  - b. If no, please explain why and give examples.

16. What does it mean to say that “Scientific knowledge is subjective”? Do you agree with this statement? Provide a detailed explanation of your answer including examples from your daily life.
17. How did your research reflect your beliefs and values? Give examples. If you do not agree that it did reflect your beliefs and values explain why and give examples.

APPENDIX E  
STUDENT INTERVIEW PROTOCOL

### Student Interview Protocol

**Interview #1:** Students' life histories (with a focus on previous school and science experiences). The goal of this first interview is to gain a deeper understanding of my students' lives outside of my classroom and at school.

Reminders:

- Interviews should be 45 to 60 min
- Let them talk
- Bring snacks and extra batteries
- Take notes

1. Tell me about your family and neighborhood where you live.
2. What do you like to do outside of school?
3. What are you an expert in?
4. What grade school did you attend?
5. Tell me about the things you liked about your grade school
6. Tell me about the things you would change about your grade school.
7. Describe your science classes in grade school.
8. Tell me about the things you liked about science in grade school.
9. Tell me about the things you didn't like about your science classes in grade school.
  - a. *If need more info:* Describe some of your experiences in your grade school science classes.
10. How did you feel when you were in your grade school science class?
11. What would you change about your grade school science class?
12. How did you end up attending St. Rita?
13. Tell me about the things you like about St. Rita.

14. Tell me about the things you would change about St. Rita.

Schedule next interview (approximately 3 days later)

**Interview #2:** Students' experiences with the Sci-YAR curriculum. The goal of this interview is to elicit the students' accounts of their experiences with the Sci-YAR curriculum. This interview will focus on the students recounting the details of their research projects, not to reflect on their experiences.

Reminders:

- Ask for examples or to tell you more to keep them talking
- Bring snacks and extra batteries
- Take notes

1. What is science?
2. What makes science different from your other classes/subjects?
3. What is action research?
4. Do you need to conduct experiments or research to understand science?
  - a. If yes, explain why and give an example
  - b. If no, explain why and give an example
5. Do scientists need to conduct experiments or research to understand science?
  - a. If yes, explain why and give an example
  - b. If no, explain why and give an example
6. What effect has science had on your life?
7. Why did you pick the topic you did?
8. What are the steps you took to conduct your action research?
9. Describe the process of conducting your research project. Begin in January and walk me through what you can to June.
10. Why did you choose the methodology that you did (interviews, etc)?
11. Describe the day of the research symposium. Begin with when you woke up that morning until you went to sleep.
12. What did you enjoy the best about conducting your research?
13. How would you do your project differently if you could?
14. Is conducting your research project similar to the work of scientists?
  - a. If yes, explain why and give an example
  - b. If no, explain why and give an example
15. Did the work you did with your research project impact any aspect of your life outside of school?
  - a. If yes, explain why and give an example
  - b. If no, explain why and give an example

Schedule next interview (approximately 3 days later) & Give student homework to pick pseudonym

**Interview #3:** Students' reflections on the meaning of the experiences discussed in the second interview. In this this final interview, I will ask students to reflect on the meaning of their experiences with the Sci-YAR curriculum, and in particular with their research projects.

1. Why do you think I had you guys conduct your own research as a part of my class?
2. Should I continue with the action research projects in my biology classes next year? Why or why not.
3. What should I change? What should I keep the same?
4. What are the overall benefits of conducting this type of research?
5. What advice would you give my future students?
6. Before you began your research, what did you think about science?
7. What do you think about science now?
8. How did you feel conducting your research?
9. How did you feel making decisions on what you learn in my class?
10. I had you do a lot of reflection in my class specifically the journals and the picture frames.
  - a. Why do you think I had to do that?
  - b. What is beneficial? Why or why not?
  - c. How should I change the journals or picture frames for next year?
  - d. Do scientists reflect?
11. How did your research reflect your beliefs and values? Give examples. If you do not agree that it did reflect your beliefs and values explain why and give examples.

12. Did you use creativity and imagination during your research?

- a. If yes, at which stages of your research did you use your creativity and imagination?
- b. If no, please explain why and give examples.

Get pseudonym and explain that you will compile a summary of their responses for them  
to approve

APPENDIX F  
RECRUITMENT SCRIPT



## **Science Teaching and Learning as Transformation: Making Meaning with My Students**

### **Recruitment Script (to be read in person)**

As you know, my name is Mrs. Coleman and I am a classmate of Ms. Leider's at Loyola University – Chicago. Ms. Leider would like to ask you to take part in a research study being done by Ms. Leider for a dissertation.

You are being asked to participate because you are in one of Ms. Leider's biology courses at St. Rita of Cascia High School. As a part of this course, you engage in Sci-YAR research projects, where you conduct an action-based science project on a topic you chose. In a group with your classmates, you pose questions about a particular problem or issue, collect and analyze data related to those questions, and then publically share your results along with possible solutions. You also keep records of your experiences and thought about what these experiences meant to you as a person and a researcher. Since all students in Ms. Leider's biology classes (approximately 60) did a project, all are being invited to participate in this study.

The purpose of this study is to examine what your experiences are like while engaging in the Sci-YAR curriculum. Ms. Leider would like to find out more about your reactions to participating in Sci-YAR and conducting these research projects. In addition, she want to see how engaging in Sci-YAR impacts areas of your lives both inside and outside of the classroom.

If you agree to participate in the study, you will allow Ms. Leider access to any items you created in class such as written assignment, journals and your final research presentations. In addition, you will be interviewed by Ms. Leider three times over the summer for approximately one hour each. The interviews will be about your experiences engaging in the Sci-YAR curriculum specifically about your previous school and science experiences as well as about your experiences that you found most meaningful.

If you have questions about this research study, please feel free to contact me at 773.898.2511 or at [ecoleman3@luc.edu](mailto:ecoleman3@luc.edu). I will be recruiting participants for this study and will not inform Ms. Leider as to who wishes to participate until after final grades have been submitted. In addition, I am familiar with this study and can answer any questions you might have.

If you would like to participate in this research study, please return the signed assent form along with your parents' signatures on the consent form in a sealed envelope to be in person or by mail to:

Mrs. Elizabeth Coleman  
820 N. Michigan Ave  
Lewis Towers, 10<sup>th</sup> Floor  
Chicago, IL 60611

Any Questions?

## APPENDIX G

### CONSENT TO PARTICIPATE IN RESEARCH COVER LETTER

Dear Parent/Guardian of St. Rita Student,

In addition to teaching science at St. Rita, I am also a doctoral student at Loyola University Chicago in the Ed.D. Curriculum and Instruction program. I have been working on my dissertation for the past several months and have recently defended my dissertation proposal titled, “Science Teaching and Learning as Transformation: Making Meaning with My Students”. I will be conducting my research in my classroom at St. Rita and would like to study students’ experiences with engaging in the science youth action research (Sci-YAR) curriculum.

Your child is being asked to participate because he is currently in one of my biology courses. As you are aware, as part of this class, your son is participating in Sci-YAR instruction. In a group with his classmates, your child is posing questions about a particular problem or issue, collecting and analyzing data related to those questions, and then publically sharing his results along with possible solutions. In addition, your student is also keeping records of his experiences and is challenged to think about what these experiences mean to him as a person and a researcher. I am asking all students who conducted these projects consider being a part of my research so I can better understand what students’ experiences are like doing this type of project.

I have secured official letters of support from the Office of Catholic Schools and from Mr. Conroy, so that I may conduct this study at St. Rita. A colleague of mine from Loyola University, Mrs. Elizabeth Coleman will be recruiting students to participate in this study. Mrs. Coleman has spoken to the class as a whole, described what their participation in this research would potentially entail, and answered any questions that were asked. I am asking that you review the attached consent form, and if you agree to allow your child to participate in this study, that you initial and sign the form, and have your child return it to Mrs. Coleman in a sealed envelope or by mail along with their own signed assent form. Mrs. Coleman will hold on to these forms until final grades have been submitted in June. I will not know who has agreed to participate until after final grades have been submitted, thus ensuring that your student’s grades are unaffected by their participation in the study. I have included Mrs. Coleman’s contact information on the consent form. She is familiar with this study and will be available to discuss the study in greater detail or answer any questions you might have.

Thank you for your time and consideration.

Sincerely,

Megan Leider

APPENDIX H

CONSENT TO PARTICIPATE IN RESEARCH

## **Consent to Participate in Research**

**Project Title:** Science Teaching and Learning as Transformation: Making meaning with my students

**Researcher:** Ms. Megan Leider

**Faculty Sponsor:** Dr. Ann Marie Ryan

### **Introduction:**

Your student is being asked to take part in a research study being done by Ms. Leider for a dissertation under the supervision of Dr. Ann Marie Ryan in the School of Education at Loyola University of Chicago. He is being asked to participate because he is in my biology course at St. Rita of Cascia High School. As a part of this course, he engages in Sci-YAR curriculum in which he conducts action-based science projects on a topic of his group's choosing. In a group with his classmates, your student poses questions about a particular problem or issue, collects and analyzes data related to those questions, and then publically shares his results along with possible solutions. He also keeps records of his experiences and thought about what these experiences meant to him as a person and as a researcher. Since all students in my biology classes (approximately 60 students) are working on a project, all are being invited to participate in this study. Ms. Leider will not know which students have agreed to participate in this study until after the course ends and final grades have been submitted. Please read this form carefully and ask any questions you may have before deciding whether you allow your son to participate in the study.

### **Purpose:**

The purpose of this study is to examine what youth's experiences are like while engaging in the Sci-YAR curriculum. I would like to find out what are students' reactions to this curriculum and to conducting these research projects. In addition, I want to see how engaging in Sci-YAR impacts students' lives both inside and outside of the classroom.

### **Procedures:**

If you allow your child to participate in the study, he will be asked to:

\_ Allow Ms. Leider access to any artifacts he created in class, such as written assignments, journal entries, and final research projects and presentations.

\_ Engage in a series of three (3) one-hour to ninety minute interviews with Ms. Leider. The interviews will take place between June and August of 2014 and each of the three interviews will take place approximately four days apart. Interviews will take place at the school or another place picked by you and your student and will occur at a time convenient for you and your student. The questions asked in each interview will be about your student's experiences with the Sci-YAR curriculum and with conducting the research project. Questions will ask about his previous school and science experiences as well as about his experiences with the instruction and projects and what parts of the instruction and projects he found the most meaningful. These interviews will help me

understand your student's experiences in my classroom. Each of these interviews will be audio recorded.

**Risks/Benefits:**

There are no foreseeable risks involved in participating in this research. It is possible that he might experience some discomfort engaging in research activities outside of class. For example, he may feel uncomfortable answering questions about his experiences doing the project, providing negative comments about the project, or having the interviews audio recorded. Your student's participation in this study will have no impact on his grade in my class. I will not know who is participating in this study until after final grades have been submitted.

I anticipate that engaging in the Sci-YAR curriculum, completing this research project, and participating in this research will have certain benefits for your student. A potential benefit is that he may want to take action by using science to improve his life and the lives of those in his community. This could also create future benefits for society. This study will also potentially benefit him and others by helping teachers understanding why youth might not like science or science classes and give them ideas for making science classes better.

**Confidentiality:**

In order to protect the confidentiality of your student the following precautions will be taken:

\_ The other teachers and administrators at St. Rita will be unaware as to which students decide to participate in the study (unless you or your student chooses to share that information voluntarily with them), and no data collected from the interviews outside of class will be shared with any other school personnel. In all written reports of the research your confidentiality will be maintained by using a pseudonym (fake name) and by removing any information from comments made that could link those comments directly back to you.

\_ Data will only be collected and accessed by Ms. Leider, and all data will be stored in a password protected file or in a locked cabinet. The audio recordings of all interviews will be transcribed and stored in a password protected file. As data is collected and transcribed, identifying information will be taken out and your name will be replaced with a numerical code. Only Ms. Leider will have access to the linking codes, which will be kept secure in a password protected file.

\_ Original audio files will be completely destroyed within three years of the completion of the study.

**Voluntary Participation:**

Participation in this study is voluntary. If you or your student does not want to participate in this study, he does not have to participate. Even if he decides to participate, he is free not to answer any question or to stop participating at any time. If he withdraws from the study, no more data will be collected from him. You and your student's decision to

participate will have no effect on your student's overall participation in the biology course and no impact on his grade in the course.

You and your student may also agree to only participate in particular parts of the study. Please initial next to the research activities that you and your student agree to participate in. I agree to:

\_\_\_\_\_ Allow Ms. Leider access to any artifacts I created in class, such as written assignments, journal entries, and final research projects and presentations.

\_\_\_\_\_ Engage in a series of three (3) one-hour to ninety minute interviews with Ms. Leider which will be audio recorded.

### **Contacts and Questions:**

If you have questions about this research study, please feel free to contact Elizabeth Coleman at 773.898.2511 or at [ecoleman3@luc.edu](mailto:ecoleman3@luc.edu), or the faculty sponsor, Dr. Ann Marie Ryan at 312.915.6232 or at [aryan3@luc.edu](mailto:aryan3@luc.edu). Mrs. Coleman will be recruiting participants for this study and will not inform Ms. Leider as to who wishes to participate until after final grades have been submitted. In addition, Mrs. Coleman is familiar with this study and can answer any questions you might have.

If you have questions about your rights as a research participant, you may contact the Loyola University Office of Research Services at 773-508-2689.

### **Statement of Consent:**

Your signature below shows that you have read the information provided above, have had an opportunity to ask questions, and agree to allow your child to participate in this research study. You will be given a copy of this form to keep for your records.

\_\_\_\_\_  
**Parent/Guardian's Signature Date**

\_\_\_\_\_  
**Researcher's Signature Date**

This consent form must be returned to Mrs. Elizabeth Coleman in a sealed envelope or by mail to:

Mrs. Elizabeth Coleman  
820 N. Michigan Ave  
Lewis Towers, 10<sup>th</sup> Floor  
Chicago, IL 60611



APPENDIX I  
ASSENT TO PARTICIPATE IN RESEARCH

## **Assent to Participate in Research**

**Project Title:** Science Teaching and Learning as Transformation: Making meaning with my students

**Researcher:** Ms. Megan Leider

**Faculty Sponsor:** Dr. Ann Marie Ryan

### **Introduction:**

You are being asked to take part in a research study being done by Ms. Leider for a dissertation under the supervision of Dr. Ann Marie Ryan in the School of Education at Loyola University of Chicago.

You are being asked to participate because you are in my biology course at St. Rita of Cascia High School. As a part of this course, you engage in Sci-YAR research projects, where you conduct an action-based science project on a topic you chose. In a group with your classmates, you pose questions about a particular problem or issue, collect and analyze data related to those questions, and then publically share your results along with possible solutions. You also keep records of your experiences and thought about what these experiences meant to you as a person and a researcher. Since all students in Ms. Leider's biology classes (approximately 60) did a project, all are being invited to participate in this study. Please read this form carefully and ask any questions you may have before deciding whether to participate in the study.

### **Purpose:**

The purpose of this study is to examine what youth's experiences are like while engaging in the Sci-YAR. I would like to find out what are students' reactions to participating in Sci-YAR and with these research projects. In addition, I want to see how engaging in Sci-YAR impacts areas of students' lives both inside and outside of the classroom.

### **Procedures:**

If you agree to participate in the study, you will be asked to:

\_ Allow Ms. Leider access to any artifacts you created in class, such as written assignments, journal entries, and final research projects and presentations.

\_ Engage in a series of three (3) one-hour to ninety minute interviews with Ms. Leider. The interviews will take place between June and August of 2014 and each of the three interviews will take place approximately four days apart. Interviews will take place at the school or another place picked by you and your parents and will occur at a time convenient for you and your parents. The questions asked in each interview will be about your experiences engaging in the Sci-YAR curriculum. Questions will ask about your previous school and science experiences as well as about your experiences with the instruction and projects and what parts of the instruction and projects you found most meaningful. These interviews will help me understand your experiences in my classroom. Each of these interviews will be audio recorded.

**Risks/Benefits:**

There are no foreseeable risks involved in participating in this research. It is possible that you might experience some discomfort engaging in research activities outside of class. For example, you may feel uncomfortable answering questions about your experiences doing the project, providing negative comments about the project, or having the interviews audio recorded. Your participation in this study will have no impact on your grade in my class. I will not know who is participating in this study until after final grades have been submitted. I anticipate that engaging in Sci-YAR instruction, completing this research project, and participating in this research will have certain benefits for you. A potential benefit is that you may want to take action by using science to improve your own life and the lives of those in your community. This could also create future benefits for society. This study will also potentially benefit you and others by helping teachers understanding why youth might not like science or science classes and give them ideas for making science classes better.

**Confidentiality:**

In order to protect your confidentiality the following precautions will be taken:

\_ The other teachers and administrators at St. Rita will be unaware as to which students decide to participate in the study (unless you choose to share that information voluntarily with them), and no data collected from the interviews outside of class will be shared with any other school personnel. In all written reports of the research your confidentiality will be maintained by using a pseudonym (fake name) and by removing any information from comments made that could link those comments directly back to you.

\_ Data will only be collected and accessed by Ms. Leider, and all data will be stored in a password protected file or in a locked cabinet. The audio recordings of all interviews will be transcribed and stored in a password protected file. As data is collected and transcribed, identifying information will be taken out and your name will be replaced with a numerical code. Only Ms. Leider will have access to the linking codes, which will be kept secure in a password protected file.

\_ Original audio files will be completely destroyed within three years of the completion of the study.

**Voluntary Participation:**

Participation in this study is voluntary. If you do not want to be in this study, you do not have to participate. Even if you decide to participate, you are free not to answer any question or to stop participating at any time. If you withdraw from the study, no more data will be collected from you. Your decision to participate will have no effect on your overall participation in the biology course and no impact on your grade in the course. You may also agree to only participate in particular parts of the study. Please initial next to the research activities that you agree to participate in. I agree to:

\_\_\_\_\_ Allow Ms. Leider access to any artifacts I created in class, such as written assignments, journal entries, and final research projects and presentations.

\_\_\_\_\_ Engage in a series of three (3) one-hour to ninety minute interviews with Ms. Leider which will be audio recorded.

**Contacts and Questions:**

If you have questions about this research study, please feel free to contact Elizabeth Coleman at 773.898.2511 or at ecoleman3@luc.edu, or the faculty sponsor, Dr. Ann Marie Ryan at 312.915.6232 or at arian3@luc.edu. Mrs. Coleman will be recruiting participants for this study and will not inform Ms. Leider as to who wishes to participate until after final grades have been submitted. In addition, Mrs. Coleman is familiar with this study and can answer any questions you might have.

If you have questions about your rights as a research participant, you may contact the Loyola University Office of Research Services at 773-508-2689.

**Statement of Assent:**

Your signature below shows that you have read the information provided above, have had an opportunity to ask questions, and agree to participate in this research study. You will be given a copy of this form to keep for your records.

---

**Participant's Signature Date**

---

**Researcher's Signature Date**

This assent form must be returned to Mrs. Elizabeth Coleman in a sealed envelope or by mail to:

Mrs. Elizabeth Coleman  
820 N. Michigan Ave  
Lewis Towers, 10<sup>th</sup> Floor  
Chicago, IL 60611

## APPENDIX J

### REMINDER LETTER TO PARTICIPATE IN RESEARCH

June 6, 2014

Dear [Participant's Parents and Participant]

Thank you again for your consent and willingness to participate in my dissertation study "Science Teaching and Learning as Transformation: Making Meaning with My Students".

The purpose of this study is to examine what my students' experiences are like while engaging in the Sci-YAR curriculum and conducting their research projects. In addition, I want to see how engaging in Sci-YAR impacts areas of students' lives both inside and outside of the classroom.

I have been informed by Elizabeth Coleman that you have agreed to allow me access to your work created in class, such as written assignments, journal entries, and final research projects and presentations. I will also interview you three times this summer. Each interview will be approximately one hour in length and each interview will take place approximately four days apart. Interviews will take place at the school or another place picked by you and your parents and will occur at a time convenient for you and your parents. The questions asked in each interview will be about your experiences engaging in the Sci-YAR curriculum; your previous school and science experiences; and your experiences with the instruction and projects and what parts of the instruction and projects you found most meaningful. These interviews will help me understand your experiences in my classroom. Each of these interviews will be audio recorded.

I would also like to remind you that your participation in this study is completely voluntary and you are free to refuse to answer any question. In addition, your confidentiality will be maintained using multiple measures including using a pseudonym (fake name) and removing any information from comments made that could link those comments directly back to you.

I will be contacting you in the next week to set up interview dates and locations. If you have questions about this research study before that time, please feel free to contact me at 847.846.1089 or at [mleider@stritahs.com](mailto:mleider@stritahs.com)

Thank you,

Megan Leider

APPENDIX K  
INITIAL DATA ANALYSIS CODE LIST

<b>SELF-STUDY</b>	
<b>CPS</b>	Challenges power structures
<b>TF</b>	Teacher as facilitator
<b>TT</b>	Teacher transformation
<b>MT</b>	Learning about myself as a teacher
<b>LS</b>	Learning from my students
<b>PR</b>	Positive reactions to Sci-YAR
<b>NR</b>	Negative reactions to Sci-YAR
<b>OR</b>	Other reactions to Sci-YAR
<b>AS</b>	Sci-YAR affects other relationships at school
<b>AH</b>	Sci-YAR affects other relationships at home
<b>PerR</b>	Sci-YAR affects personal relationships
<b>ProR</b>	Sci-YAR affects professional relationships
<b>FPC</b>	Future plans and career



<b>PHENOMENOLOGICAL STUDY</b>	
<b>LrnE</b>	Learning about themselves as experts
<b>LrnS</b>	Learning about themselves as students
<b>LrnT</b>	Learning about themselves as thinkers
<b>SPR</b>	Student positive reactions
<b>SNR</b>	Student negative reactions
<b>SOR</b>	Student other reactions
<b>SAS</b>	Sci-YAR affects student at school
<b>SAH</b>	Sci-YAR affects student at home
<b>SPerR</b>	Sci-YAR affects students with personal relationships

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## VITA

Megan Leider was born and raised in Grayslake, Illinois. Both she and her brothers attended Catholic grade school and high school. While in high school at Carmel Catholic in Mundelein Illinois she learned the importance of hair mousse, blue eye shadow and friendship. It was early on in her schooling when Megan's parents and teachers instilled in her a passion for Catholic education.

Upon graduation, Megan attended Marquette University and earned a Bachelor's degree in Biology with a minor in Philosophy (it made sense at the time). After graduating from college, Megan spent a year volunteering in the AmeriCorps. It was at this time that she finally realized that she was called to be a teacher. Megan soon returned to get her Master's and teaching certification from Roosevelt University and began teaching at Holy Trinity High School. After nine years at Holy Trinity, she taught science at Christ the King Jesuit College Prep School and is currently at St. Rita of Cascia on the city's southwest side where she teaches AP biology, freshmen biology, and environmental science and is the Science Department Chair.

Megan currently lives in the Logan Square neighborhood of Chicago and enjoys fitness, carbohydrates, and television. She would be remiss if she did not mention that she has a really awesome cat, Oliver. Really, he is a cool cat. Even if you don't like cats you will most likely like Oliver. He is like dog but really he is a cat. Trust me, he is a chill cat. Let me know if you want to come over to see him.

## DISSERTATION COMMITTEE

The dissertation submitted by Megan M. Leider has been approved by the following committee

Ann Marie Ryan, Ph.D., Director  
Associate Professor and Program Chair, Teaching and Learning  
Loyola University Chicago

Dave Ensminger, Ph.D.  
Assistant Professor, Teaching and Learning  
Loyola University Chicago

Lara Smetana, Ph.D.  
Assistant Professor, Teaching and Learning  
Loyola University Chicago